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SILVER BOW CREEK

REMEDIAL INVESTIGATION FINAL REPORT
APPENDIX E, PART 1

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SILVER BOW CREEK REMEDIAL INVESTIGATION
DRAFT FINAL REPORT

MACROINVERTEBRATE REPORT

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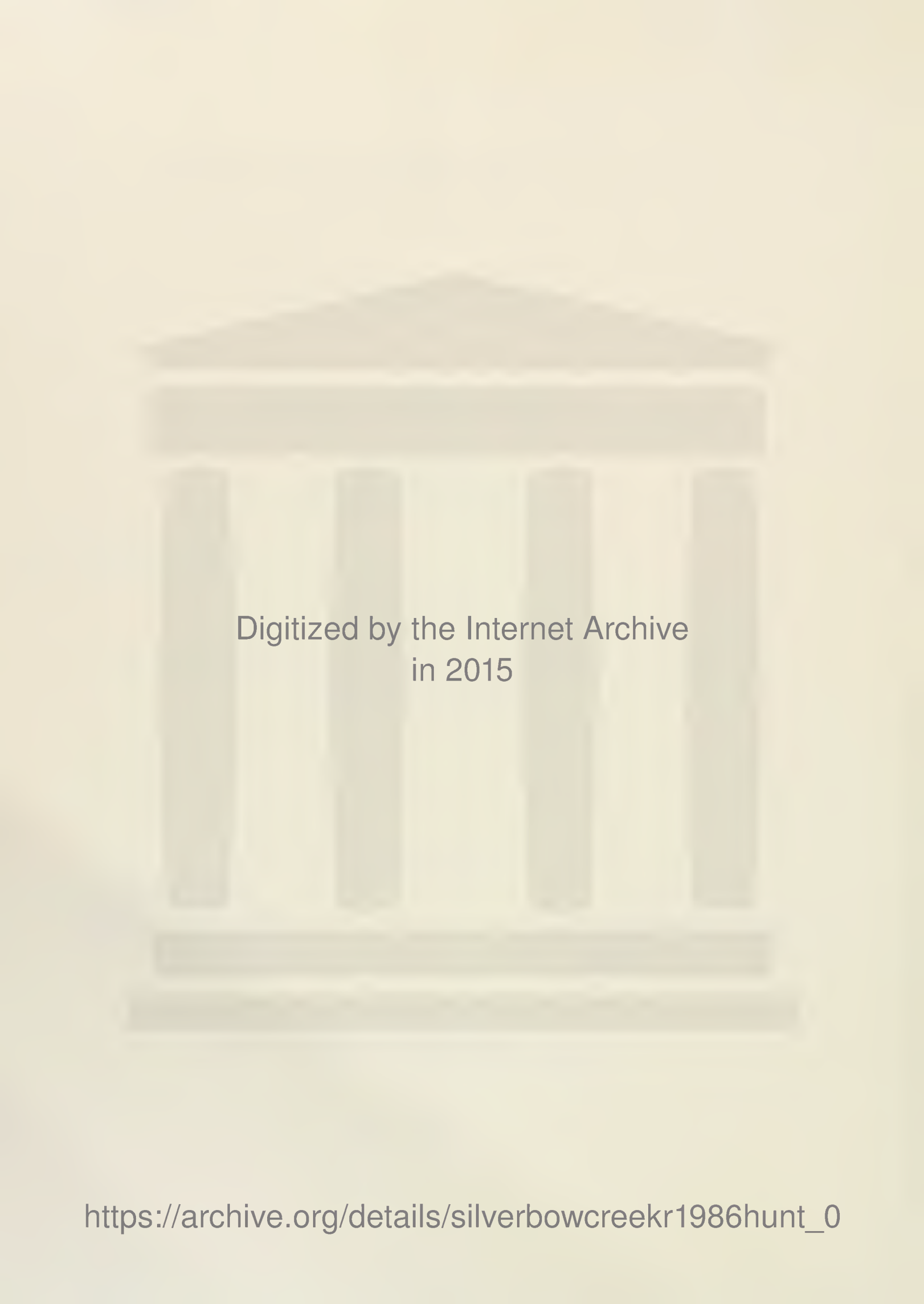
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PREFACE

Silver Bow Creek originates north of Butte, Montana and is a major tributary to the upper Clark Fork River. Mill tailings and other mining wastes in and near the creek contribute to substantial downstream contamination, particularly by potentially toxic elements: arsenic, cadmium, copper, lead, iron, and zinc. These elements and others were present in the mine ore and remain as by-products of the milling and smelting processes.

The history of mining in the Butte area began with the discovery of placer gold in Silver Bow Creek, in late summer of 1864. Several townsites and camps sprung up among the diggings. However, these operations were short-lived, and most of the miners left by 1869. Those who stayed began prospecting the quartz lode deposits of silver and the associated complex copper ores on the Butte Hill. Their efforts culminated in a silver rush, which began in the mid-1870's and revived the old camp. During that time world-class deposits of copper ore were identified. By 1881, Butte had become one of the nation's major mining centers; the district attained national dominance in copper mining by the mid-1890's and international prominence by the turn of the century. By 1915, Anaconda Copper Mining Company led the industry; but in 1980, in response to a depressed copper market, Anaconda closed all the underground mines and continued active mining only in the Berkeley Pit (established in 1955). In 1977, Anaconda became a subsidiary of Atlantic Richfield Company (ARCO). ARCO closed the Berkeley Pit in 1982 and the East Berkeley pit in 1983.

In addition to mining, various ore processing facilities also operated in the Butte area. The first two mills were erected in 1874 to smelt gold and silver. Ten years later, Marcus Daly, one of the founders of the Anaconda Company, built a copper smelter 27 miles west of Butte and planned the city of Anaconda. The Anaconda Smelter was moved to a new location in the city in 1900, and operated from 1903 to 1980.

The history of over 100 years of continuous mining and related activities changed the area's natural environment greatly. Early mining, milling, and smelting wastes were dumped directly into Silver Bow Creek and transported downstream to the Clark Fork River. In 1911, the first treatment pond was built by Anaconda Company near Warm Springs, Montana, to settle out wastes from Silver Bow Creek before the water was allowed to move on. In 1916 and 1959, two more treatment ponds began operation. Silver Bow Creek continued to receive raw mining and milling wastes until 1972, when a treatment plant was added to the Weed Concentrator in Butte. Creek contamination problems were compounded by urban and domestic sewage, wood products treatment plants, phosphate and manganese production facilities, and chemical factories.

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In 1983, the U.S. Environmental Protection Agency (USEPA) designated Silver Bow Creek, contiguous portions of the upper Clark Fork River, and their environs as a high priority Superfund clean-up site. The site extends from Butte to Deer Lodge, Montana, generally following the course of Silver Bow Creek and the upper Clark Fork River. Because the various mining activities interrupted the natural flow of Silver Bow Creek, the beginning of the creek for this investigation was established as the confluence of the Metro Storm Drain and Blacktail Creek, within the city limits of Butte. The site begins at the start of the Metro Storm Drain and ends at the Kohrs Bridge north of Deer Lodge.

The Silver Bow Creek Remedial Investigation (SBC RI) project consisted of coordinated individual studies to develop data on the extent and severity of contamination within the site. Results of the studies are reported in several volumes. A Summary Final Report discusses the entire project; final reports for each individual study have been issued as appendices to the Summary, as shown below:

- Surface Water and Point Source Investigation, Appendix A, Parts 1-3;
- Ground Water and Tailings Investigation, Appendix B, Parts 1-3;
- Warm Springs Ponds Investigation, Appendix C;
- Algae Investigation, Appendix D, Part 1;
- Vegetation Mapping, Appendix D, Part 2;
- Agriculture Investigation, Appendix D, Part 3;
- Macroinvertebrate Investigation, Appendix E, Part 1;
- Bioassay Investigation, Appendix E, Part 2;
- Fish Tissue Investigation, Appendix E, Part 3;
- Waterfowl Investigation, Appendix E, Part 4; and
- Laboratory Quality Assurance/Quality Control Program, Appendix F.

The Solid and Hazardous Waste Bureau (SHWB) of the Montana Department of Health and Environmental Sciences (MDHES) administered the USEPA appropriations to conduct this project. The Montana SHWB program manager was Mr. Michael Rubich. MDHES contracted with MultiTech in October 1984 to perform the SBC RI under contract No. 50341-1202503. The Project Manager at MultiTech was Mr. Gordon Huddleston.

MultiTech was assisted in the SBC RI work by Stiller and Associates of Helena and various other subcontractors. Several state and federal agencies also provided technical information and expertise, including the USEPA bioassay team, the Montana Department of Fish, Wildlife and Parks, the Montana Water Quality Bureau, and the USEPA Montana Field Office.

Information developed in the SBC RI will be used in the next phase of the project, the Feasibility Study, to evaluate options for site remediation.

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EXECUTIVE SUMMARY

The objectives of the Macroinvertebrate Investigation were to evaluate the historical and current biological conditions of Silver Bow Creek and the upper Clark Fork River using macroinvertebrates (aquatic insects) as bioindicators, and to quantify this baseline information for use in measuring the success of subsequent remedial actions on this CERCLA Site.

A comprehensive analysis of all available macroinvertebrate data showed that improvements in water quality were generally paralleled by an increase in the number and diversity of aquatic insect communities. Macroinvertebrates in the Clark Fork River near Deer Lodge, Montana, show a general pattern of improvement from a diversity range of 0.6 to 1.6 in the early to mid-1970's to diversity values of 2.1 to 3.6 between 1981-1984. Silver Bow Creek near Butte, Montana was nearly devoid of aquatic life during the 1970's, but had macroinvertebrate diversity values of 2.0 to 2.7 from 1981 to 1984. Although these data indicate a significant improvement in biological conditions within the Upper Clark Fork drainage area, existing conditions in Silver Bow Creek are still well below the macroinvertebrate diversity values of 3.0 to 4.0 generally found in clean waters.

Continued monitoring and evaluation of macroinvertebrates in Silver Bow Creek and the Upper Clark Fork is recommended as an important tool for gaging the overall effectiveness and long-term success of remedial actions on the Silver Bow Creek CERCLA Site.

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1.0 INTRODUCTION

The objective of the Silver Bow Creek Remedial Investigation (SBC RI) is to determine the extent and severity of contamination in Silver Bow Creek and the upper Clark Fork River (Map 1-1). A timeline of the major events that led to the contamination of this system are found in Figure 1-1. The major identified sources of contaminants in this area are tailings deposits and contaminated ground water (see SBC RI Surface-Water and Ground-Water Reports, Appendices A and B). The contaminants being investigated by the SBC RI are arsenic (As), cadmium (Cd), copper (Cu), iron (Fe), lead (Pb), and zinc (Zn).

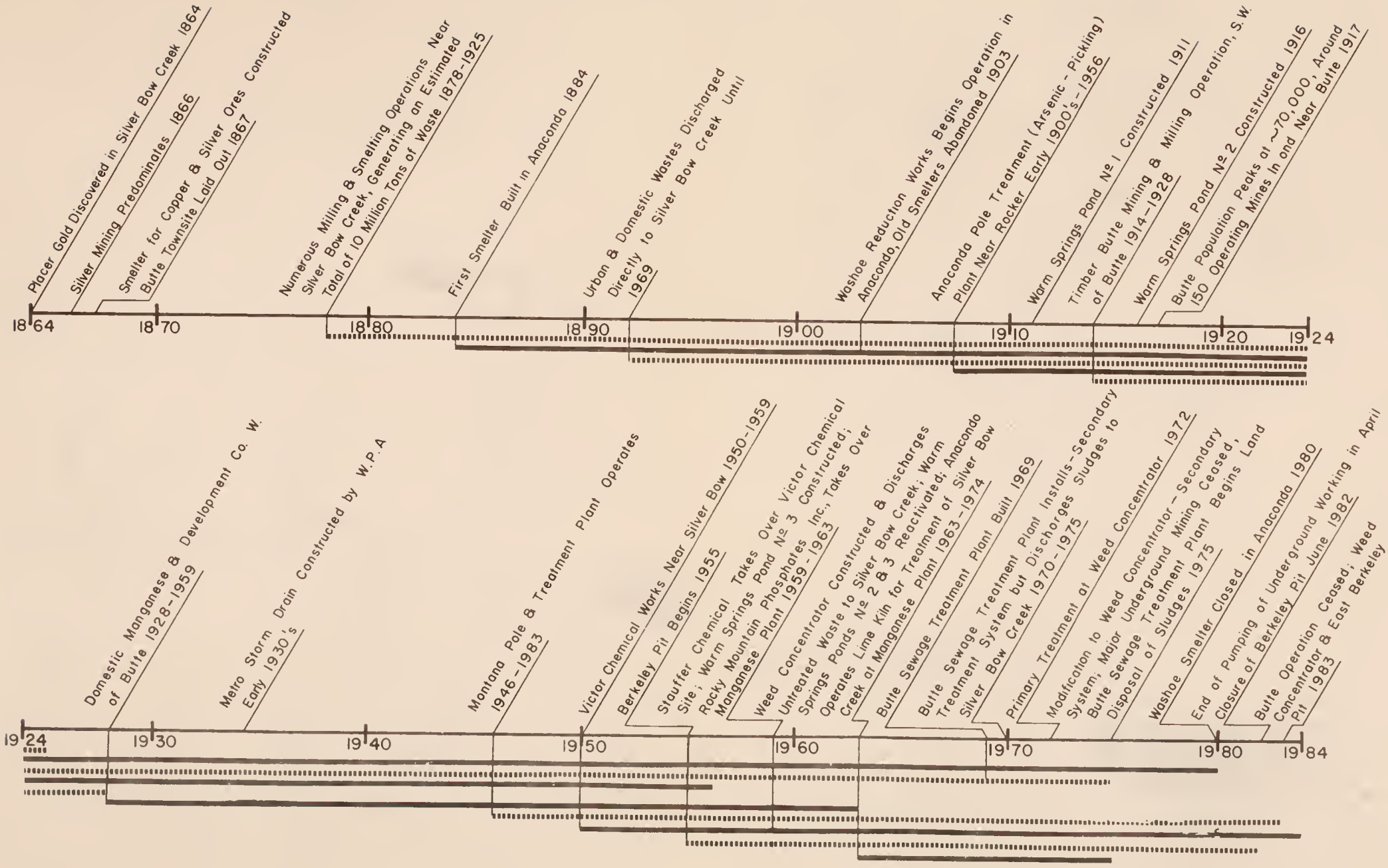
Data developed by the SBC RI will be used to evaluate human risk from the contaminants and to identify potential remedial actions. These activities will occur as part of the Feasibility Study (FS), the next phase of action for the Silver Bow Creek site.

1.1 STUDY PLAN DEVELOPMENT AND OBJECTIVES

The types and species of organisms that reside in an aquatic environment are determined by the characteristics of that hydrologic system. In aquatic ecosystems the characteristics that determine the communities inhabiting that system include physical characteristics such as depth, gradient, substrate, and temperature; and chemical characteristics such as dissolved oxygen; presence, absence, or concentrations of elements and compounds; and pH. The organisms inhabiting any given aquatic system are adapted for living in that particular suite of

FIGURE 1-1

HISTORIC CONTAMINATION OF SILVER BOW CREEK


Placer Gold Discovered in Silver Bow Creek 1864
Silver Mining Predominates 1866
Smelter for Copper & Silver Ores Constructed
Butte Townsite Laid Out 1867
Numerous Milling & Smelting Operations Near Silver Bow Creek, Generating an Estimated Total of 10 Million Tons of Waste 1878-1925
First Smelter Built in Anaconda 1884
Urban & Domestic Wastes Discharged Directly to Silver Bow Creek Until 1969
Washoe Reduction Works Begins Operation in Anaconda, Old Smelters Abandoned 1903
Anaconda Pole Treatment Plant Near Rocker Early 1900's-1956
Warm Springs Pond Nº 1 Constructed 1911
Timber Butte Mining & Milling Operation, S.W. of Butte 1914-1928
Warm Springs Pond Nº 2 Constructed 1916
Butte Population Peaks at ~70,000, Around 150 Operating Mines In and Near Butte 1917
1864
1870
1880
1890
1900
1910
1920
1924
Domestic Manganese & Development Co. W. of Butte 1928-1959
Metro Storm Drain Constructed by W.P.A Early 1930's
Montana Pole & Treatment Plant Operates 1946-1983
Victor Chemical Works Near Silver Bow 1950-1959
Berkeley Pit Begins 1955
Stauffer Chemical Site; Warm Springs Pond Nº 3 Constructed; Rocky Mountain Phosphates Inc., Takes Over Manganese Plant 1959-1963
Takes Over Victor Chemical
Weed Concentrator Constructed & Discharges Untreated Waste to Silver Bow Creek; Warm Springs Ponds Nº 2 & 3 Reactivated; Anaconda Operates Lime Kiln for Treatment of Silver Bow Creek at Manganese Plant 1963-1974
Butte Sewage Treatment Plant Built 1969
Butte Sewage Treatment Plant Installs-Secondary Treatment System but Discharges Sludges to Silver Bow Creek 1970-1975
Primary Treatment at Weed Concentrator 1972
Modification to Weed Concentrator-Secondary System, Major Underground Mining Ceased; Butte Sewage Treatment Plant Begins Disposal of Sludges 1975
Washoe Smelter Closed in Anaconda 1980
End of Pumping of Underground Working in April Closure of Berkeley Pit June 1982
Butte Operation Ceased; Weed Concentrator & East Berkeley Pit 1983
1924
1930
1940
1950
1960
1970
1980
1984

CONTINENTAL DIVIDE
YANKEE OODLE PONO
BERKELEY PIT
BUTTE
BLACKTAIL CR.
BASIN CR.
LITTLE BASIN CR.
CLARK TAILINGS
COLORADO TAILINGS
ROCKER
BROWNS GULCH
SILVER BOW
RAMSAY
DAWSON
MILES CROSSING
FLINT CR.
SCALE 1" = 2.27 MILES
COTTONWOOD CR.
PETERSEN CR.
CARIBOU CR.
DRY COTTONWOOD CR.
CLARK FORK
OEER LODGE
DEMPSEY
GALEN
WARM SPRINGS PONOS
WARM SPRINGS
TAYLOR CR.
POWELL CR.
DEMPSEY CR.
RACETRACK CR.
MODESTY CR.
LOST CR.
WARM SPRINGS CR.
MILL CR.
WILLOW CR.
SILVER BOW CREEK
FAIRMONT HOT SPRINGS
GERMAN GULCH
SILVER BOW CREEK
MAP 1-1
SILVER BOW CREEK
and UPPER
CLARK FORK RIVER

characteristics. This attribute of organisms has led to the concept of bioindicators--organisms that reflect their environment--and their use for monitoring the physical and chemical characteristics of that environment.

Aquatic macroinvertebrates (large insects) are often chosen for use as bioindicators because of their relative size, ease in collection, and relatively narrow range of tolerance to ecosystem characteristics. For the SBC RI, aquatic macroinvertebrates were selected for use as bioindicators (1) to determine the current biological status of Silver Bow Creek and (2) to provide data on baseline conditions (prior to any remedial action).

A literature review of Silver Bow Creek macroinvertebrates revealed that the existing data were sufficient to achieve the above two goals. However, the data were scattered among several reports by different authors.

To facilitate the post-remediation monitoring and comparisons and to provide a coherent view of the existing biological status of Silver Bow Creek, the SBC RI Work Plan (MultiTech and Stiller and Associates 1984) recommended a report to summarize the existing data. This report has three objectives:

- Present and summarize all baseline data available in the literature on aquatic insects for Silver Bow Creek and the upper Clark Fork River;

- Review this data to evaluate the current status of Silver Bow Creek and the upper Clark Fork River; and

- Evaluate this data for use in measuring the success of the remedial actions.

1.2 HISTORICAL DATA

Past work on the macroinvertebrates of Silver Bow Creek and the upper Clark Fork River was performed by the following researchers: Spindler (1959), Averett (1961), U.S. Environmental Protection Agency (USEPA) (1972), Fox (1972), USEPA (1974), Metz (1976), Dent (1974-76), Janik and Melancon (1982), and two consultants to the Anaconda Minerals Company (1981-84). Their work was reviewed to complete this report.

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2.0 METHODS

The data collected by the various authors was reviewed critically for applicability to the objectives of the current investigation. The review included comparability of data based upon the methods used in data collection by the authors. The review also included a determination of the statistical validity of these studies and their implications for the SBC RI.

2.1 DATA COLLECTION

Meaningful comparisons can be made only among studies which utilize the same stations and sampling methodologies at approximately the same time of year to collect population samples. Table 2-1 lists the sampling stations used by the various authors and provides an identification letter for each of these stations. The station locations are displayed on Map 2-1.

2.1.1 Spindler and Averett

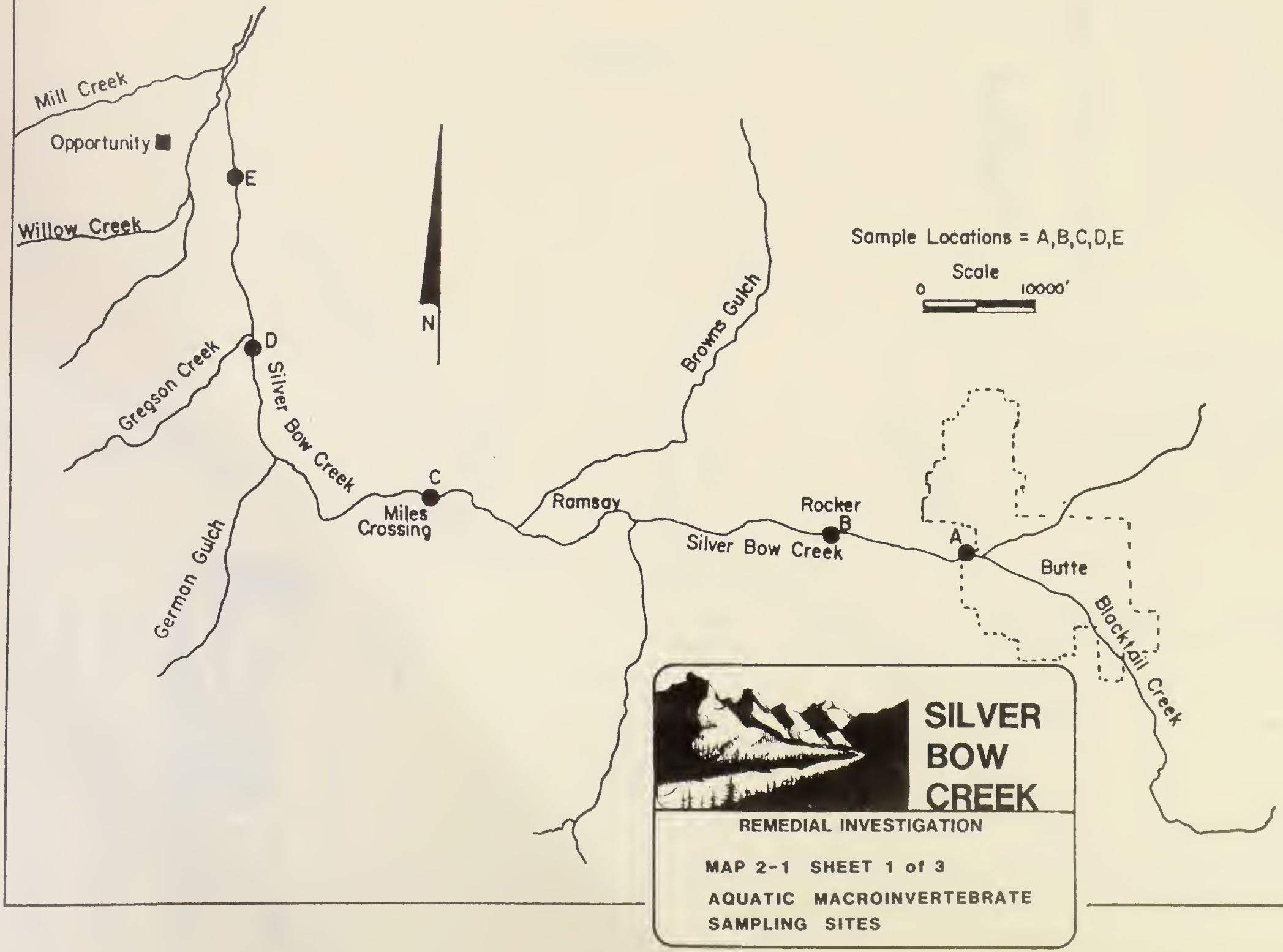
Spindler (1959) and Averett (1961) utilized a 1-ft² substrate sampler (Surber-type) and a 4-ft² sampler to make their July macroinvertebrate collections. Both authors identified organisms collected to the Order level.

TABLE 2-1
SAMPLING STATION LOCATIONS AND IDENTIFICATION LETTERS

Map 2-1 Id. Letter	Description	Spindler 1959	Averett 1961	EPA 1972	Fox 1972	EPA 1974	Metz 1976	Dent 1972-76	Janik Melancon 1982	Anaconda Minerals Co. 1981-84
A	In Butte, downstream of Montana St. Bridge				7					SBC 1
B	Upstream of Rocker, below Butte Sewage Treatment Plant	496			10					SBC 2
C	Miles Crossing, downstream of Ramsay				13		6			SBC 3
D	Upstream of Gregson Bridge near Gregson Hot Springs	476					7		026	SBC 4
E	Upstream of Stewart St. Bridge east of Opportunity				17			0		SBC 5
F	In diversion canal for Mill-Willow Crk., above Warm Springs Ponds						8	1		CF 0
G	Warm Springs Pond 2 discharge							2 A	027	CF 2A
H	In diversion canal for Mill-Willow Crk., downstream of Pond 2 discharge	473	473		18			2	023	CF 2

TABLE 2-1
SAMPLING STATION LOCATIONS AND IDENTIFICATION LETTERS
(Continued)

Map 2-1 Id. Letter	Description	Spindler 1959	Averett 1961	EPA 1972	Fox 1972	EPA 1974	Metz 1976	Dent 1972-76	Janik Melancon 1982	Anaconda Minerals Co. 1981-84
I	Clark Fork R. downstream of confluence w/Mill-Willow and Warm Springs Crks.	469	469	293030	20			4	025	CF 4
J	Clark Fork R. in Deer Lodge upstream of Milwaukee Ave. Bridge	456	456	243007		CF-1A		6		CF 6
K	Clark Fork R. upstream of Phosphate	443	443	293006		CF-2		8		CF 8


Mill Creek
Opportunity
E
Willow Creek
D
Gregson Creek
Silver Bow Creek
C
Miles Crossing
German Gulch
Ramsay
Browns Gulch
Rocker
B
A
Silver Bow Creek
Butte
Blacktail Creek
N
Sample Locations = A,B,C,D,E
Scale
0
10000'
SILVER BOW CREEK
REMEDIAL INVESTIGATION
MAP 2-1 SHEET 1 of 3
AQUATIC MACROINVERTEBRATE SAMPLING SITES

Sample Locations = F, G, H, I, J

0 Scale 10000'

J

Deer Lodge

Dempsey Creek

Clark Fork River

Modesty Creek

Galen

Dry Cottonwood Creek

N

I

Warm Springs

H

G

1

2

3

Warm Springs Ponds

Warm Springs Creek

F

Mill Creek

Willow Creek

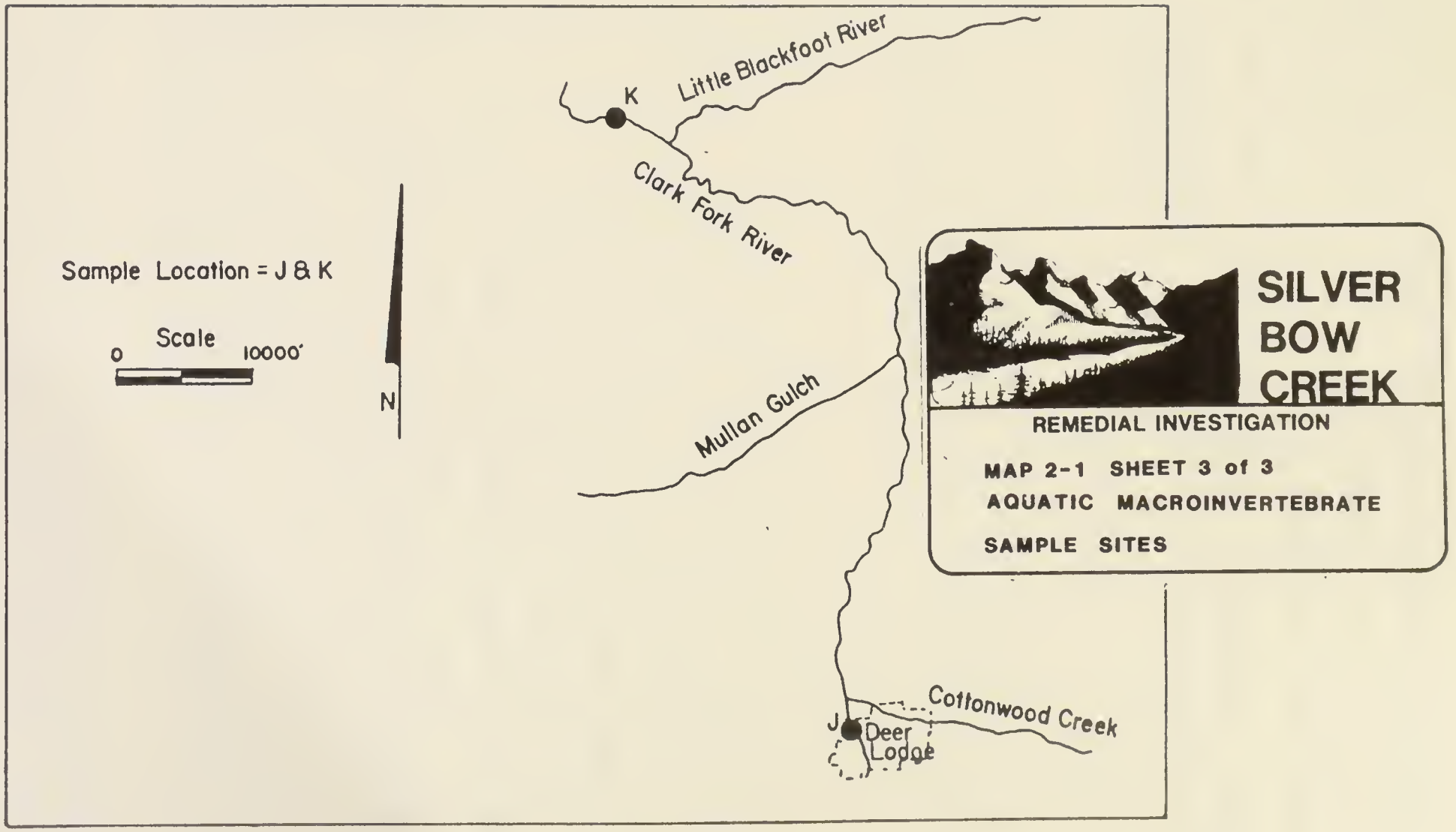
Silver Bow Creek

SILVER BOW CREEK

REMEDIAL INVESTIGATION

MAP 2-1 SHEET 2 of 3

AQUATIC MACROINVERTEBRATE SAMPLING SITES


Sample Location = J & K
Scale
0
10000'
N
K
Little Blackfoot River
Clark Fork River
Mullan Gulch
J
Deer Lodge
Cottonwood Creek
SILVER BOW CREEK
REMEDIAL INVESTIGATION
MAP 2-1 SHEET 3 of 3
AQUATIC MACROINVERTEBRATE
SAMPLE SITES

Spindler's data were reported in units showing the number of pollution-sensitive organisms as a percentage of the total number of organisms collected at that station. (Sensitive organisms are defined as belonging to the Orders Plecoptera, Trichoptera, Ephemeroptera, Odonata, and Lepidoptera). This type of analysis suffers from several substantial drawbacks:

- Pollution sensitivity cannot be generalized at the Order or Family classification levels. Such statements can safely be made at only the species level.

- Pollution in Silver Bow Creek and the Clark Fork River consists of two types: organic and trace metals. Organic pollution is contributed by municipalities via sewage discharge. The metals pollution is a result of mining, milling, and smelting activity in the area. These two types of pollution can have very different effects on macroinvertebrate populations (USEPA 1974):

  > "When moderate concentrations of organic pollution occur, sensitive organisms decrease in numbers and kinds while tolerant organisms can increase in numbers (due to lack of competition for food, space, etc.). The effect is that total numbers may increase while the number of taxa decreases. The discharge of toxic materials may eliminate all aquatic invertebrates. However, in most instances a reduction in both numbers and kinds of organisms, with no corresponding increase in tolerant kinds, results."

- Spindler does not provide any information regarding the taxa present (i.e., a list of taxa found) other than the percentage and number of sensitive organisms.

Averett (1961) reported the macroinvertebrate data as number of organisms per order.

2.1.2 U.S. Environmental Protection Agency

Four papers published by the USEPA from 1972-1982 describe the results of "grab samples" of aquatic macroinvertebrates in Silver Bow Creek and the Clark Fork River.

The first of these (USEPA 1972) reports data collected during summer/fall 1970. Aquatic macroinvertebrates were collected utilizing two techniques. Artificial substrates consisting of stone-filled wire baskets were placed in the stream at each sampling point. These samplers initially were installed on May 19, 1970 and organisms were collected on June 29, August 12, and September 16, 1970. In addition, four 1-ft^2 samples were collected at each station on August 12 using a Surber sampler. Aquatic insects collected were identified to Family level and enumerated. Statistics calculated included average number of taxa per square foot, taxa percent occurrence, and diversity index.

The percent occurrence of taxa was calculated by dividing the total number of different taxa found throughout the study area for the year sampled into the total number of different taxa collected at each station.

The diversity index is a way of summarizing data on total numbers and total taxa in a single number. The diversity index is highly

influenced by sample size. Generally, the numbers of individuals per taxa and total taxa are better indicators than the diversity index.

Two of the remaining three USEPA studies utilized the Surber square-foot sampler to make April (Fox 1972) and August (USEPA 1974) collections. Organisms collected were identified to Family and enumerated. Fox (1972) reported number of organisms per square foot. USEPA (1974) computed equitability, diversity and number of organisms per square foot. Equitability is another measure of diversity computed by dividing the number of taxa in a sample by the hypothetical maximum number of taxa.

2.1.3 Metz

Metz (1976) conducted a winter study of macroinvertebrates found in Silver Bow Creek for a special topics biology class at the Montana College of Mineral Science and Technology, Butte. Aquatic insects were collected from riffle areas in January using a Surber square-foot-sampler. Organisms collected were identified to the Family level and enumerated. The diversity index was reported.

2.1.4 Janik and Melancon

Janik and Melancon (1982) utilized two different techniques to collect aquatic macroinvertebrates during August 1980. The traveling unit-

effort kick method described by Kinney et al. (1978) was used at four of five stations. Portable Invertebrate Box Samples were collected at the fifth site, where large boulder substrate made kick sampling ineffective. Organisms collected were identified to species where possible and enumerated. Total number of individuals and taxa were reported, as was relative species abundance.

2.1.5 Anaconda Minerals Company

In September 1972, the Anaconda Minerals Company initiated annual monitoring of aquatic macroinvertebrate populations in Silver Bow Creek and the Clark Fork River that continued through 1984 (Dent 1976; Harner-White Ecological Consultants 1982; Chadwick and Associates 1983, 1984, 1985). Dent's stations were all located below the Warm Springs Ponds. Macroinvertebrate population samples were collected in the fall (September) each year utilizing a Waters-Knapp circular 1-ft^2 sampler. Three samples were collected from a riffle area at each station. Aquatic insects collected were identified to family and enumerated. Statistics calculated included the Shannon-Weaver diversity index, which is less influenced by sample size than the earlier described diversity index.

The work of Harner-White Ecological Consultants (1982) and Chadwick and Associates (1983, 1984, 1985) was a modified continuation of Dent's work. Several Clark Fork River stations were discontinued and five stations on Silver Bow Creek were added. The sampling methodology and dates remained the same. Where possible, macroinvertebrate

identifications were taken to genus and species. The authors reported numbers per m^2, number of taxa, Shannon-Weaver diversity index, and mean biomass (grams per m^2 - wet weight).

2.2 DATA COMPARISON CRITERIA

Those studies which utilized the same sampling stations, methodologies, and time of year includes the work of Dent (1976), Chadwick and Associates (1983, 1984, 1985), and Harner-White Ecological Consultants (1982). These studies contain continuous data from the 1972-1984 field seasons and are compared directly in Section 3.0 of this report. Other studies such as Metz (1976), USEPA (1974), and Janik and Melancon (1982) can be used to corroborate this work, but cannot be compared directly due to differences in sampling stations, methodologies, and sampling dates.

Most of the studies compared in Section 3.0 of this report present taxa identified, numbers per taxa, diversity indices, biomass, and density measurements for each station for each sampling period.

The number of taxa present indicates the quality of the environment: a population with a large number of taxa present is in a healthier environment than one dominated by just a few species (USEPA 1974). The diversity formulas derive from this basic concept, and they are designed to show the relationship between number of taxa and number of individuals in a sample.

Type of taxa also is important because of the bioindicator concept: certain taxa can live in defined environments and not in others. If insects which tolerate metals are found, but no insects which are sensitive to metals, the conclusion can be drawn that a given environment contains concentrations of metals.

Taxa identified and number of taxa are non-numerical measurements that require only similar sampling methods, dates, and stations for comparative purposes. Diversity indices require a measurement of numbers of individuals per unit area (density), and, as explained below, density measurement requires that statistical criteria be met.

Density is the number of insects per unit area, and biomass is the weight of the sample (the greater the number of insects per sample, the heavier the sample). These numbers can be misleading as to the health of an aquatic envrionment, if viewed alone. Many forms of environmental stress can reduce diversity, but increase biomass (USEPA 1974). In evaluating the quality of a stream environment, biomass and density must be evaluated with number of taxa.

For derived measurements (diversity, biomass, and density) the statistical validity of the samples is important to achieve a known degree of confidence in the computations. Determining the statistical validity of sampling efforts and derived measurements requires consideration of several elements (Elliott 1971):

- Dimensions of sampling. The largest number of samples should be collected, using the smallest possible sampling unit, within practical (manpower) limitations.

- Location of sampling units. The location is an area usually selected in a stratified, random manner. The sampling area is divided into several strata (pool, riffle, glide) and sampling units are collected randomly within each strata.

- Large number of sampling units. The larger the number of sampling units collected per sample, the greater the statistical validity. While large samples (N greater than 50) are preferable, the size of small samples can be calculated for a specified degree of precision.

All the compared studies used the common practice of a circular square-foot sampling unit for their sampling dimension. They all also collected samples from riffle areas. However, no calculations were made for precision with the small samples taken; in addition, the mean number and standard deviation of insects per sampling unit and biomass were not reported. The statistical significance of the diversity, biomass, and density estimates, therefore, could not be determined with a known degree of confidence between years or stations.

Due to the limitations of the diversity, biomass, and density measurements, these data were not compared quantitatively in this report.

However, the objective of describing the biological condition of Silver Bow Creek could still be met by comparing number and type of taxa and looking at trends in the derived values (diversity, density, and biomass).

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3.0 DATA INTERPRETATION AND ANALYSIS

The data collected in the reviewed studies are generalized and interpreted here. Attachment I presents of complete data summaries for reports reviewed.

Several concepts in field ecology (Eberhardt 1976 and Hornig 1984) apply to the SBC RI. In the absence of man-induced disturbance or natural phenomena that substantially alter stream characteristics, changes in macroinvertebrate community composition in a downstream direction are generally gradual. Abrupt changes in the biota between adjacent upstream and downstream sites may be an indication that significant water quality changes have occurred. Although annual variations in biota may be substantial, these changes generally should be consistent between adjacent sites. Thus, between-site faunal comparisons offer good reliability for detecting impacts originating in a stream reach bracketed by adjacent upstream and downstream sites.

Hynes (1972) points out that large variations in species composition can occur for no apparent reason. During a nine-year study of a trout stream, three stations were sampled each spring using the same collection techniques. No obvious change appeared in the river over time, and yet large changes occurred in percent composition of the insect community. All three stations reflected these changes.

Patrick (in Eberhart 1976) indicates that the results of several hundred studies of stream areas have shown that often a single species

may not be of much value in indicating ecological conditions, whereas associations of species may be very valuable in indicating ecological conditions. However, a community totally dominated by one or two species implies a different set of ecological conditions (Oswood 1979).

3.1 SILVER BOW CREEK STATIONS

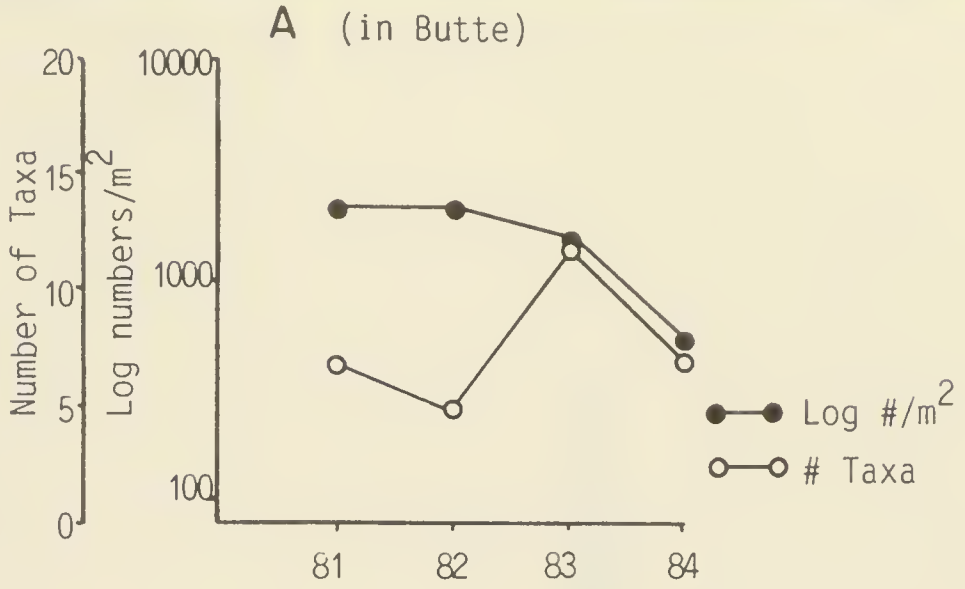
Prior to 1981, collections from stations A (in Butte), B (below Butte Sewage Treatment Plant), and C (Miles Crossing, downstream of Ramsay) revealed essentially no aquatic life. Spindler (1959) and Fox (1972) reported no insects in their collections. Metz (1976) found a total of four individuals, representing two dipteran families at station C.

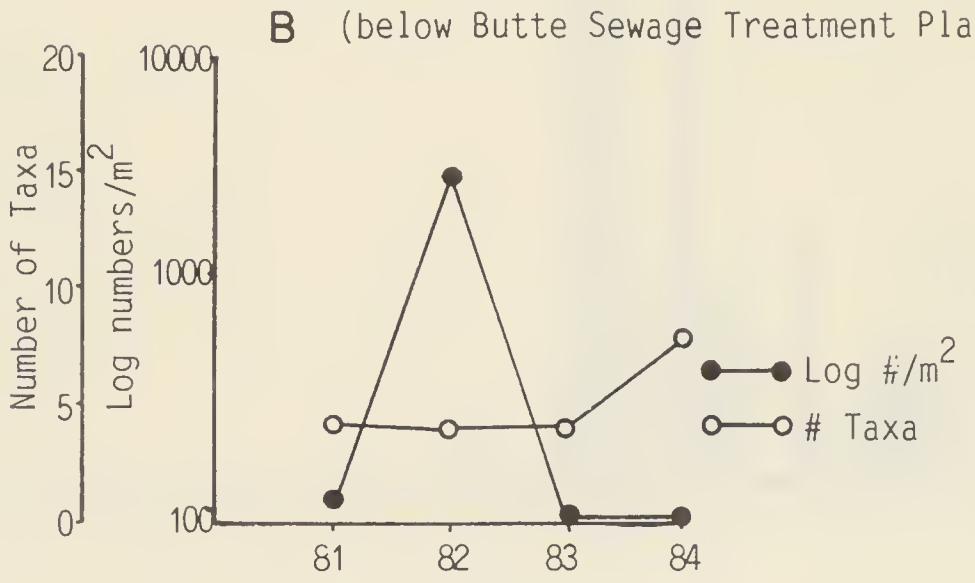
In 1981 several taxa appeared at each of these three stations. Since then the number of taxa and individuals have fluctuated (Figure 3-1). The aquatic insect communities at these stations are dominated by the Family Diptera; a few representatives of the Families Trichoptera, Plecoptera, and Ephemeroptera are present as well (Attachment I).

These three stations have low values for density (Figure 3-1) and biomass (Figure 3-2) when compared to downstream stations. The values for Shannon-Weaver diversity index (Table 3-1) are comparable to many of the Clark Fork River stations. Wilhm (1970) reported that clean waters have Shannon-Weaver diversity index values for aquatic insects ranging from 2.6 to over 4.0, with most falling in the range of 3.0 -

FIGURE 3-1

CHANGES IN AQUATIC MACROINVERTEBRATE COMMUNITY STRUCTURE, 1981-1984





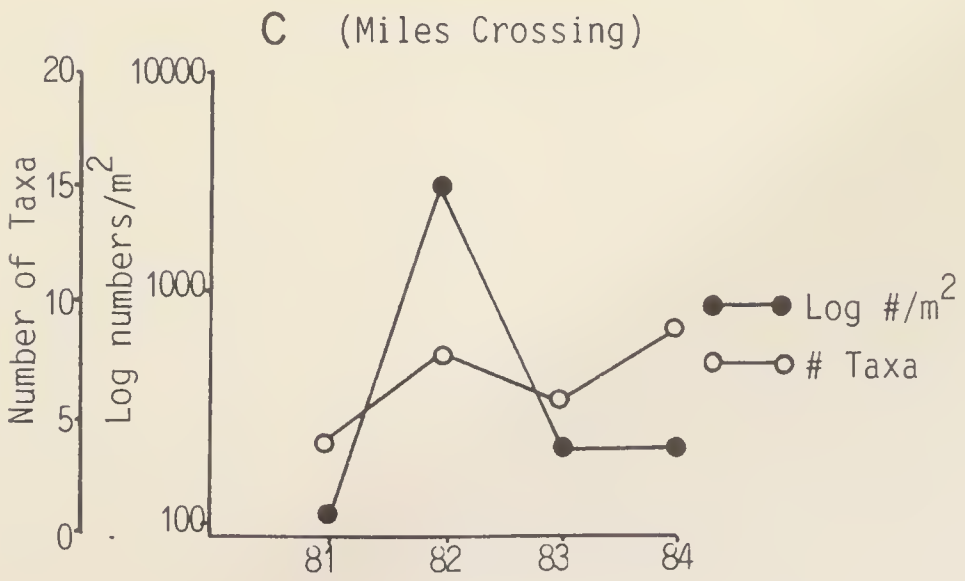


FIGURE 3-2

MEAN BIOMASS OF AQUATIC MACROINVERTEBRATES BY STATION, 1980-1984

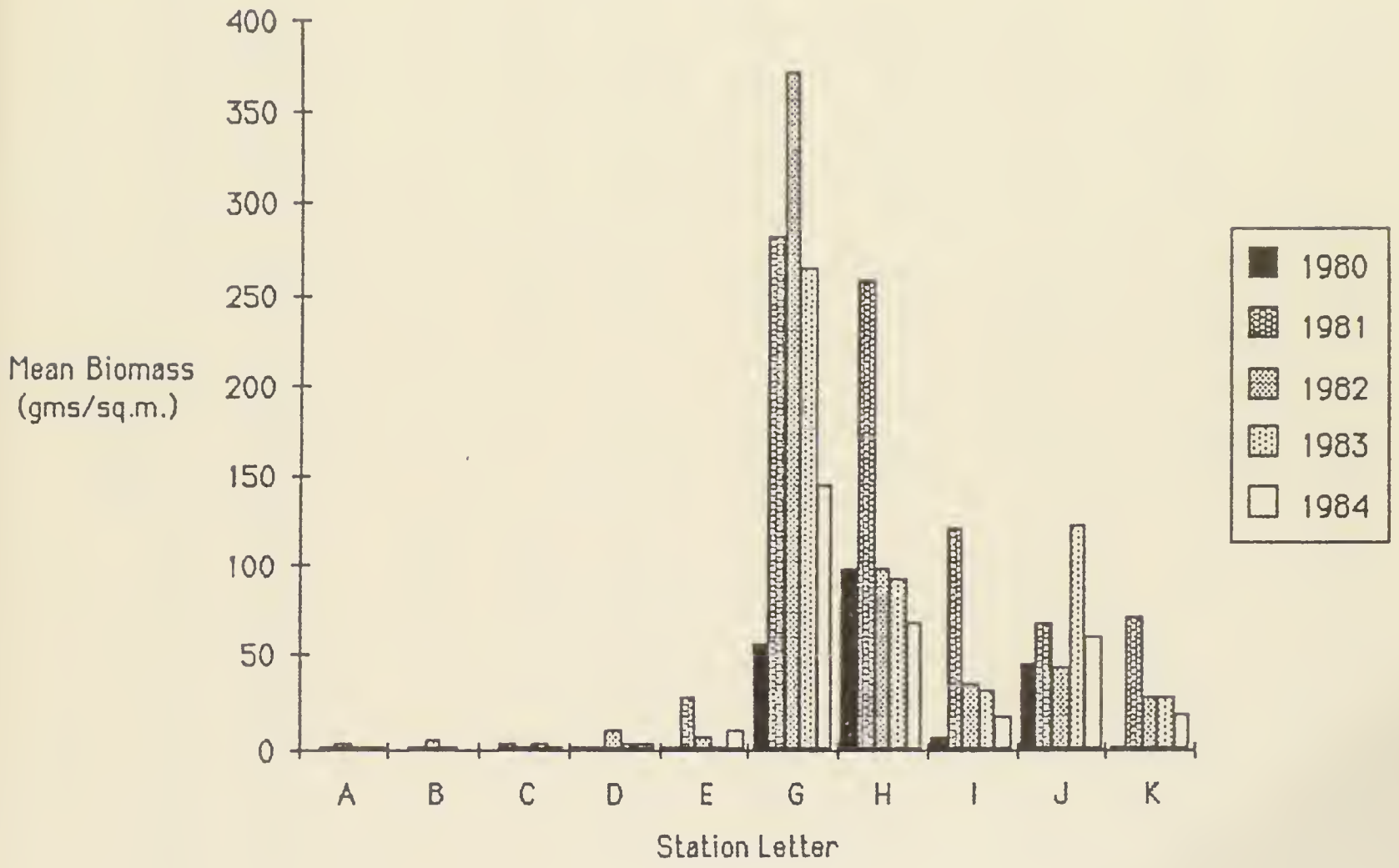


TABLE 3-1

SHANNON-WEAVER DIVERSITY VALUES AT SELECTED STATIONS

Station	1972*	1973*	1974*	1975*	1976*	1977*	1978*	1979	1980	1981	1982	1983	1984
A In Butte	-	-	-	-	-	-	-	-	-	2.22	2.55	2.51	2.72
C Miles Crossing	-	-	-	-	0.84	-	-	-	-	2.30	2.02	2.51	2.49
E Opportunity	-	-	-	-	1.10	-	0.58	1.31	2.22	1.56	1.44	2.38	1.89
F Mill-Willow Bypass	2.30	2.49	1.99	2.45	1.84	2.70	2.59	2.93	4.35	4.07	4.11	3.88	3.45
G Warm Springs Pond 2 Discharge	-	-	-	1.74	0.47	0.77	1.02	1.76	2.12	1.81	1.19	1.95	1.71
H Mill-Willow below Pond 2 Discharge	0.16	0.90	0.37	0.58	0.11	0.36	0.36	1.39	1.99	1.79	2.75	1.80	1.69
I Clark Fork River at Perkins Lane Bridge	1.50	0.57	1.63	1.32	0.72	1.55	2.01	2.67	3.07	1.94	2.12	2.84	3.55
K Clark Fork River upstream of Phosphate	1.73	2.38	2.20	1.97	2.21	2.30	1.93	3.32	3.51	2.89	3.49	2.76	2.75

* Based upon Family-level identification.

4.0. Polluted waters, on the other hand, have diversity values less than 2.0 and frequently less than 1.0.

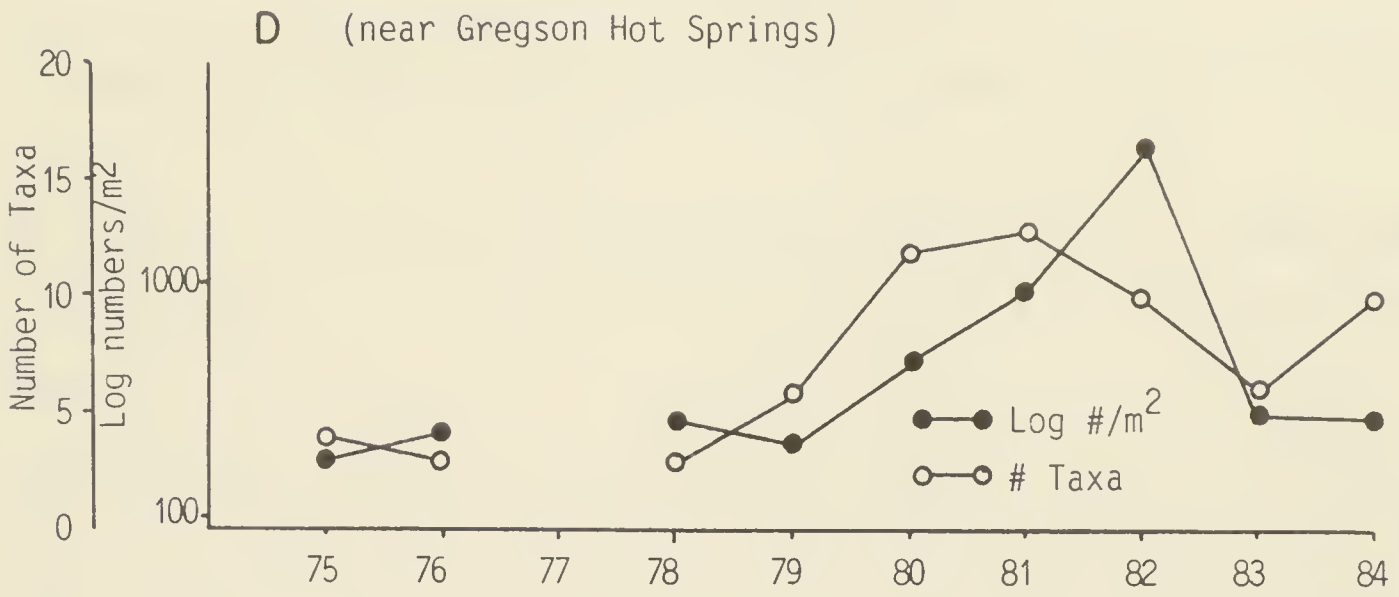
Aquatic insects have been found at stations D (upstream of Gregson Hot Springs) and E (east of Opportunity) since the 1975 collections (Figure 3-3). Dent (1976) did not find any invertebrates in Silver Bow Creek from 1972-1974. The community structure at stations D and E is similar to the upstream stations with the principal difference being in the number of filter-feeding caddis flies at these two stations. As with stations A (in Butte), B (below Butte Sewage Treatment Plant), and C (Miles Crossing), the number of taxa present and density fluctuate on a yearly basis. This fluctuation indicates the invertebrate community remains in a state of change, although densities and number of taxa have shown gradual increases since 1975.

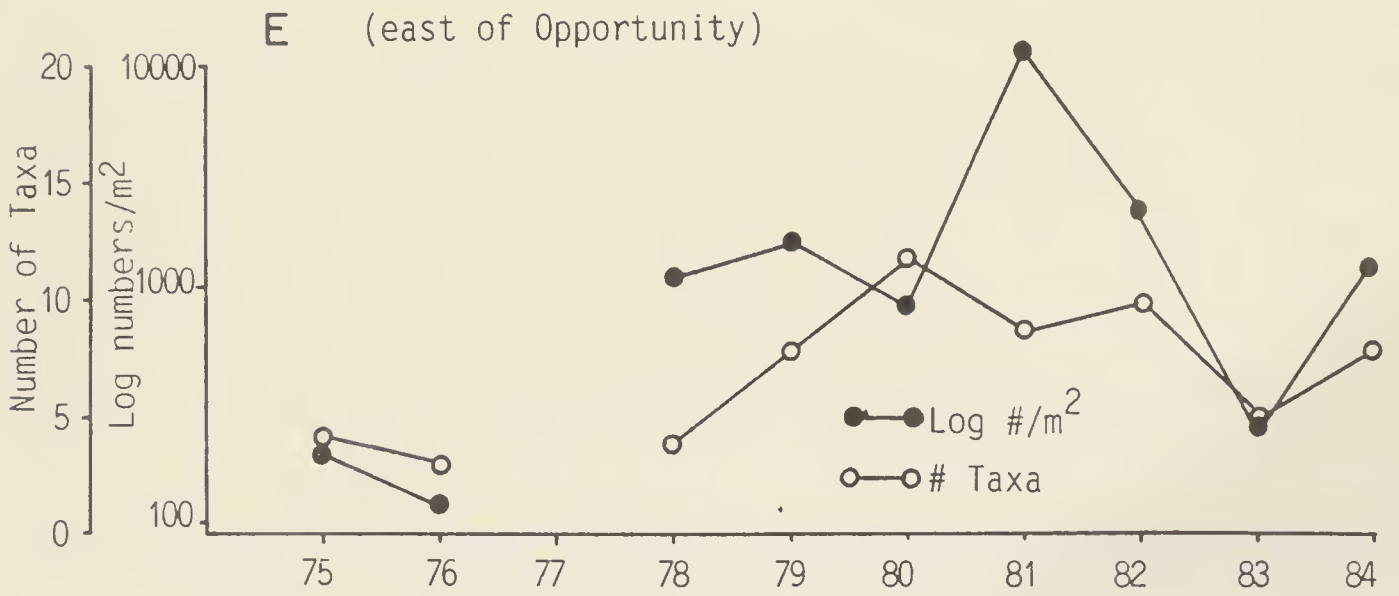
Biomass is higher and diversity lower at these stations than at the upstream stations, probably because of the large numbers of chironomid and hydropsychid larvae present (which contribute to the biomass). Their dominance, in terms of numbers, of the community structure causes the lower diversity values. Their presence indicates a source of organic enrichment upstream.

Historic water quality data, including trace metals, from a station near Opportunity was provided by MultiTech (unpublished) (data presented graphically in Attachment II). The period of record for this station is August 1975-November 1979 and December 1984-May 1985. The

FIGURE 3-3

CHANGES IN AQUATIC MACROINVERTEBRATE COMMUNITY STRUCTURE, 1975-1984





range of values for total copper, zinc, and iron for these two time periods are shown in Table 3-2.

TABLE 3-2

HISTORIC RANGE OF VALUES OF SELECTED TRACE METALS AT OPPORTUNITY

Parameter	1975-1979	1984-1985
Total copper	1.4-0.15 mg/L	0.18-0.12 mg/L
Total zinc	2.85-0.5 mg/L	0.6-0.3 mg/L
Total iron	7.5-0.4 mg/L	1.5-0.4 mg/L

This table shows that the values for total copper, zinc, and iron decreased significantly between 1979 and 1984. The graphs in Attachment II show gradually decreasing values for heavy metals from 1975-1979.

Prior to 1969 wastewater originating in Butte was not treated. The Weed Concentrator began operations and discharged untreated wastewater to Silver Bow Creek beginning in 1963. The Butte Sewage Treatment Plant (STP), a primary treatment facility, was not constructed until 1969; it also discharged directly to Silver Bow Creek.

In 1970 the Butte STP installed secondary treatment but continued to discharge sludge to Silver Bow Creek. The Weed Concentrator was upgraded with primary treatment in 1972; however, the treatment provided was not consistent. In 1975 a secondary treatment system was added to the Concentrator, and the Butte STP quit discharging sludge

to the creek. In 1983 the Butte operations closed, and consequently the discharges from the Weed Concentrator ceased (see Figure 1-1).

The aquatic insect community in Silver Bow Creek has responded directly to the discharges from Butte and most likely from the Weed Concentrator in particular. No aquatic insects were found at Silver Bow Creek stations A (in Butte), B (below Butte STP) and C (Miles Crossing) prior to 1981, and few were noted at stations D (upstream of Gregson Hot Springs) and E (east of Opportunity). With the addition of secondary treatment to the Weed Concentrator in 1972, the levels of trace metals began to decline. Improvements in water quality continued through 1979 as consistency in the operation of the treatment improved. The aquatic insects in Silver Bow Creek responded by moving into the lower reaches of Silver Bow Creek by 1975, and subsequently invading the upstream stations. As the insects moved upstream, Trichopterans became more prominent at the lower stations (D and E), indicating further recovery at these stations.

3.2 MILL-WILLOW BYPASS

Station F (Mill-Willow Bypass) is considered separately from the Silver Bow Creek stations (A-E) and the Clark Fork River stations (G-K) because the Mill-Willow Bypass is tributary to the Silver Bow Creek/Clark Fork River system. This station was incorporated into the studies undertaken by the Anaconda Minerals Company (AMC) to serve as a control station.

This station had the greatest number of taxa (40) and the highest diversity (4.11) values of any of the stations sampled. Both the mayflies and caddisflies exhibited the greatest diversity found in the study area at this station. As with several other stations, the numbers of taxa and density showed an apparently random fluctuation from year to year (Figure 3-4).

Trace metal data from water samples are available for this station for the time periods March 1975-July 1980 and December 1983-May 1985 (data are presented graphically in Attachment II). Table 3-3 presents the range of values for total copper, zinc, and lead for these time periods.

TABLE 3-3

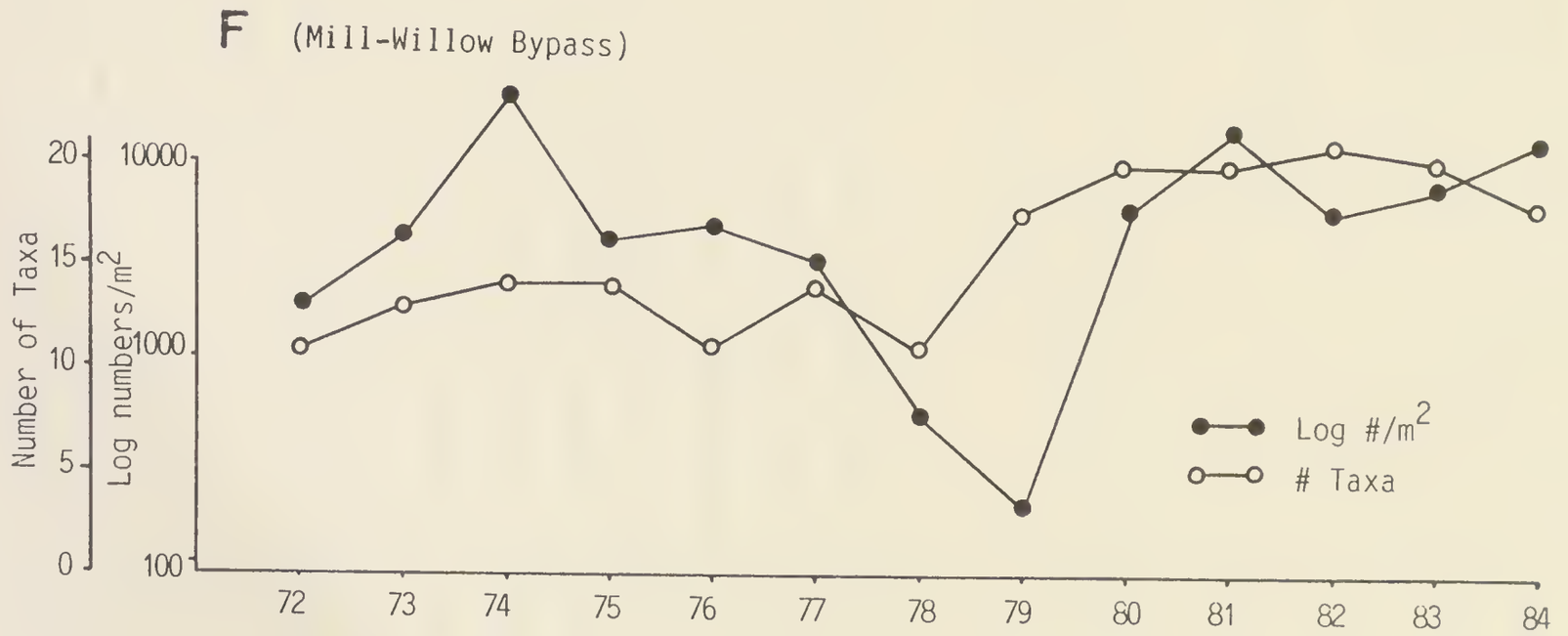
HISTORIC RANGE IN VALUES FOR TRACE METALS AT MILL-WILLOW BYPASS

Parameter	1975-1980	1983-1985
Total copper	.280-.025 mg/L	.05-.020 mg/L
Total zinc	.50-.040 mg/L	.09-.03 mg/L
Total iron	2.30-.10/mg/L	.55-.40 mg/L

These data indicate that while the absolute numbers for the concentrations of zinc and copper are much lower in Mill-Willow than in Silver Bow Creek, the trend of decreasing concentrations from 1975-1980 is the same. The same is true of the difference in the range of values between 1975-1980 and 1983-1985. During high flows, which is when trace metals concentrations peak, flow from Silver Bow Creek often

FIGURE 3-4

CHANGES IN MACROINVERTEBRATE COMMUNITY STRUCTURE, 1972-1984



exceeds the capacity of the ponds. During this time Silver Bow Creek flows are diverted into the Mill-Willow Bypass. The dilution provided by Mill-Willow accounts for the lower concentrations of zinc and copper compared to Silver Bow Creek. The lower concentrations of trace metals are reflected in the diverse and stable aquatic insect community found at this station.

3.3 CLARK FORK RIVER STATIONS

These stations start with G, which is located in the discharge canal from Warm Springs Pond 2, and continue in a downstream direction to station K, just upstream of Phosphate.

Stations G and H (diversion canal downstream of Pond 2 discharge) have the highest densities and biomass, and lowest diversity of the Clark Fork stations. These stations are dominated by filter-feeding caddis flies (Cheumatopsyche and Hydropsyche) and Dipterans (Simulium). The proliferation of these filter-feeding insects is due to the quantities of algae and other organic matter leaving the Warm Springs Ponds. Nutrient loading from upstream sewage treatment plants has made these ponds quite productive in algae. Oswood (1979) and Ward and Stanford (1979) have documented very high densities of filter-feeding insects downstream of pond and/or lake outlets.

While dominated by a few species, resulting in low diversity values (Table 3-1), both these stations have shown a gradual increase in the

numbers and diversity since 1972 (Figure 3-5). Random annual fluctuations in density and number of taxa are evident.

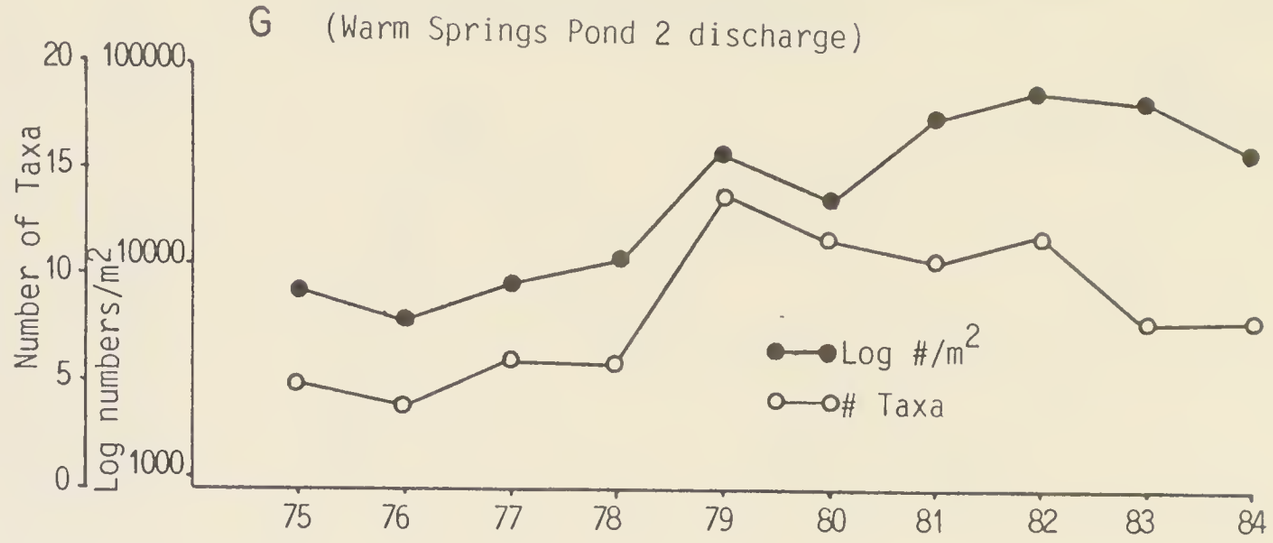
Station I (downstream of Mill-Willow and Warm Springs Creek confluence) is the first station located on the mainstem of the Clark Fork River. Since 1972 this station has shown gradually increasing numbers in taxa, diversity, density, and biomass (Figures 3-2 and 3-6). Filter-feeding insects remain an important part of the community structure as at the upstream stations. However, the community is much more diverse, with more taxa and a better numerical balance between taxa, than at the upstream sites.

Station J (in Deer Lodge) is similar in many ways to station I. It too has shown increasing density, biomass, and diversity with time (Figures 3-2 and 3-6). The filter-feeding caddis flies are important at this station, indicating that suspended organic matter is still present as a food source. Hydroptilid caddis are increasingly important at this station; they feed on filamentous algae which can be abundant at this station as well as station K (upstream of Phosphate).

Canton and Chadwick (1985) state that densities at station J are higher than at the rest of the Clark Fork stations, with the exception of station G (Warm Springs Pond 2 discharge). They suggest that a nutrient input source may exist upstream of station J. Such a nutrient source could stimulate algal growth.

FIGURE 3-5

CHANGES IN MACROINVERTEBRATE COMMUNITY STRUCTURE, 1972-1984



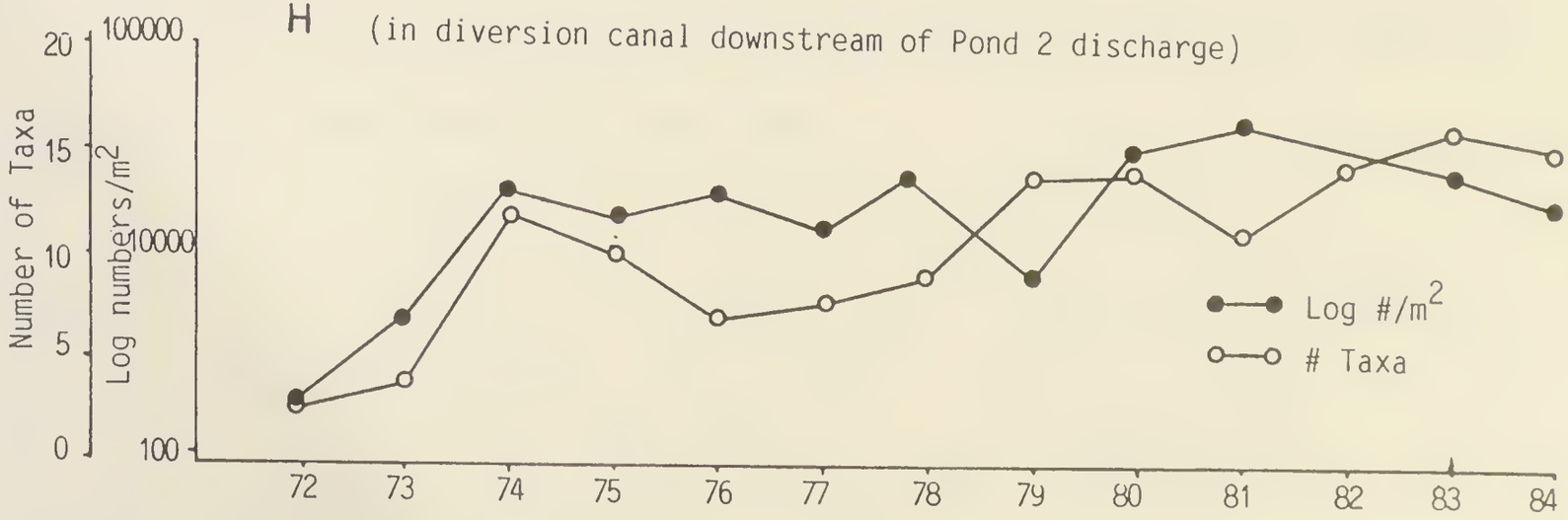
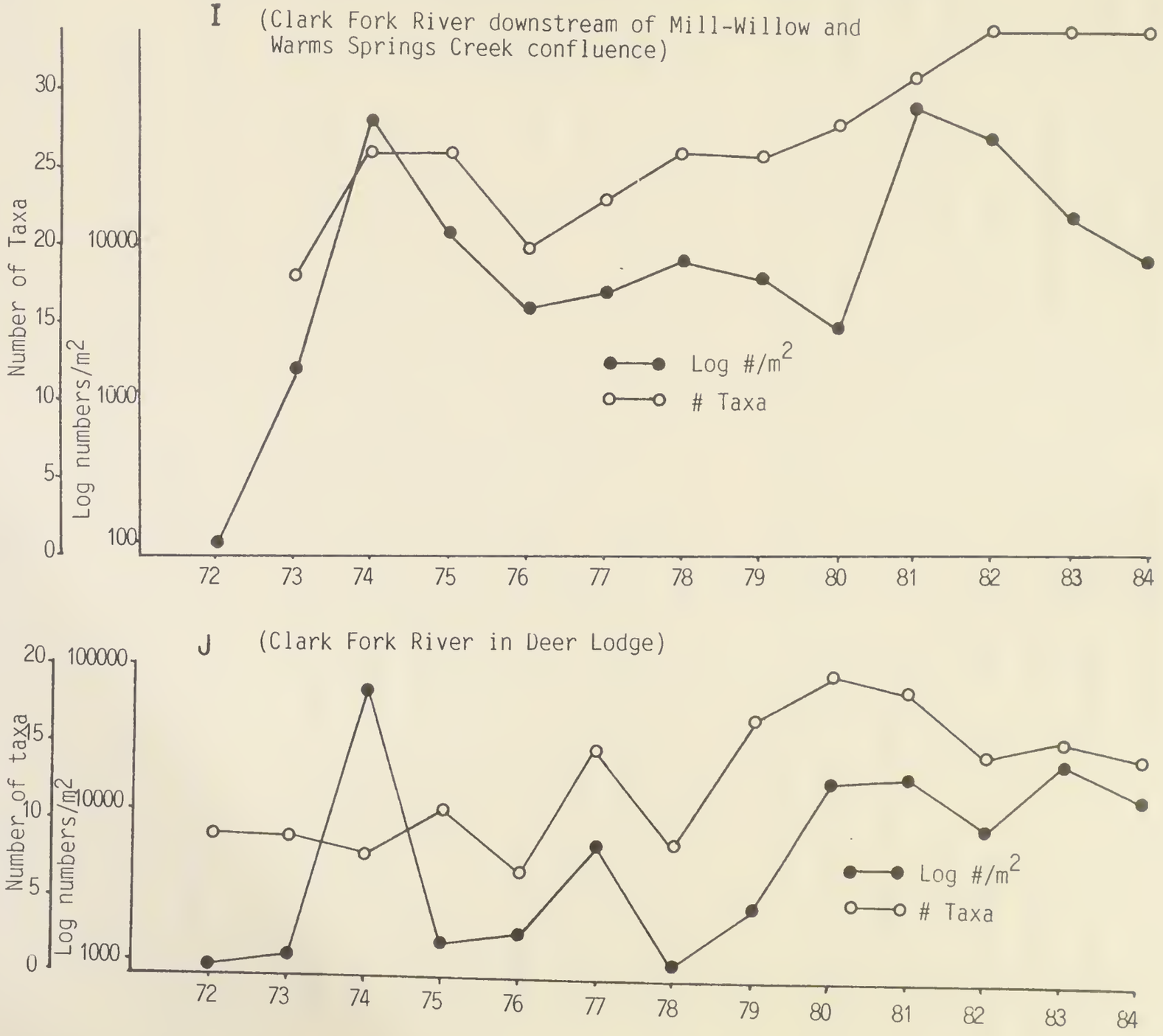


FIGURE 3-6

CHANGES IN MACROINVERTEBRATE COMMUNITY STRUCTURE, 1972-1984



Station K (upstream of Phosphate), like the upstream stations, has shown increasing densities, diversity, biomass, and number of taxa over time (Figures 3-2 and 3-7). The filter-feeding insects remain an important part of the community structure, although far downstream of the Warm Springs Ponds. The hydroptilid caddis are as important at station K as they are at station J (in Deer Lodge). Densities of macroinvertebrates at this station are not as great as at stations G (Warm Springs Pond 2 discharge) and J. They are more similar to stations F (in diversion canal above Warm Springs Ponds) and I (downstream of Mill-Willow and Warm Springs Creek confluence).

The only historic water quality data for this reach of river that includes trace metal analyses is from the Warm Springs Pond 2 discharge (Station G). The period of record for this data is March 1975-December 1981 and December 1984-May 1985 (data are presented graphically in Attachment II). Table 3-4 presents the range of values for total copper, zinc, and iron for the period of record. Unlike the data for the Opportunity and Mill-Willow Bypass, these data do not show a significant downward trend in the values for total copper, zinc, and iron for the period 1975-1981.

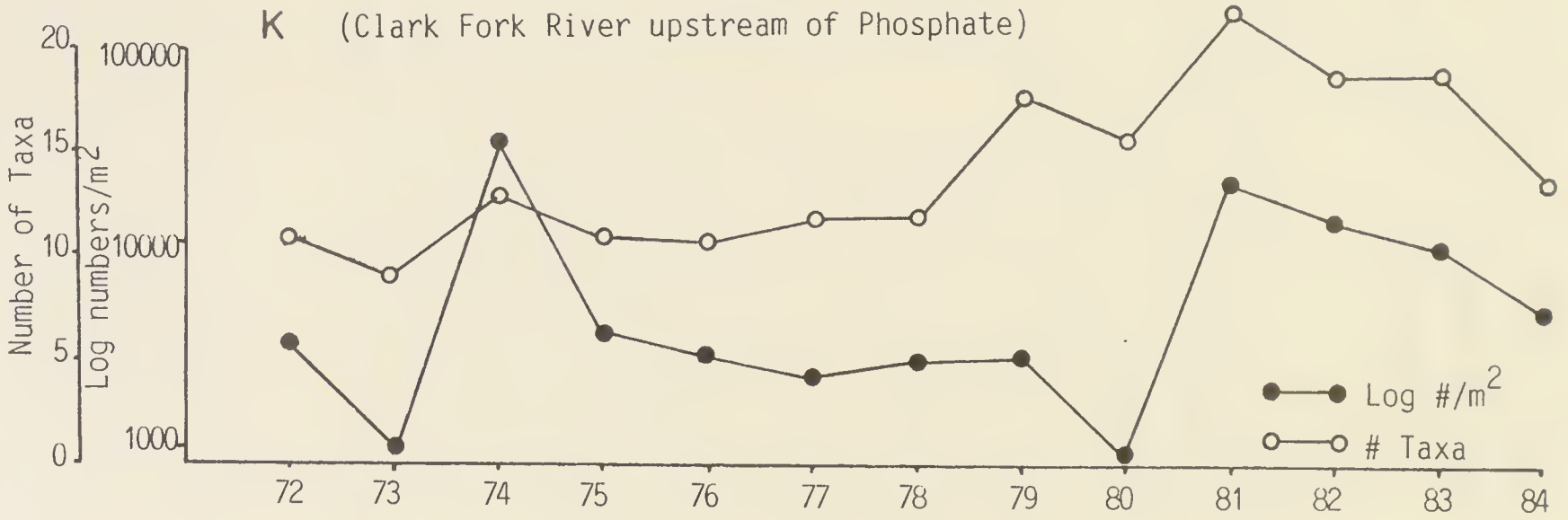
TABLE 3-4

HISTORIC RANGE OF VALUES FOR TRACE METALS IN POND 2 DISCHARGE

Parameter	1975-1981	1984-1985
Total copper	.2-.02 mg/L	.12-0.35 mg/L
Total zinc	.72-.03 mg/L	.42-.05 mg/L
Total iron	.98-.07 mg/L	1.4-.35 mg/L

FIGURE 3-7

CHANGES IN MACROINVERTEBRATE COMMUNITY STRUCTURE, 1972-1984



The values for the concentrations of these trace metals more closely resemble those for Mill-Willow Bypass than for Silver Bow Creek. This may be a result of liming Silver Bow Creek water upstream of the ponds. The addition of the lime raises the pH of the water and causes precipitation of trace metals in the ponds.

Although historic water quality data for downstream stations was not available to the reviewer, data collected by Phillips (1985) and Stiller and Associates (personal communication) in 1984 and 1985 indicates that concentrations of trace metals increase in a downstream direction from the ponds. Phillips (1985) states that iron, zinc, and copper concentrations in the Clark Fork exceed chronic toxicity criteria for protection of aquatic life. He hypothesizes that spring high flows erode copper salts from the streambanks, resulting in higher concentrations of this metal as one moves downstream from the ponds. He points out that fish population estimates for the Clark Fork River indicate highest densities of catchable brown trout right below the Warm Springs ponds. Numbers of fish decline rapidly in a downstream direction, from 1,000 fish per mile near the ponds to 400 fish per mile at Deer Lodge, and only 50 fish per mile near Bearmouth.

The aquatic insect data for the Clark Fork River stations (I-K) indicate that these stations have responded to improved water quality in the river system since 1972. However, as described by Phillips (1985) for fish, increasing levels of trace metals downstream of the ponds has possibly hindered the complete recovery of the aquatic

insect communities at the downstream stations (stations G-K). This phenomenon may account for diversity values at these stations generally below 3.

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4.0 CONCLUSIONS

The aquatic insect and water quality data reviewed clearly show that Silver Bow Creek, once devoid of insect life, is beginning to recover in response to treatment of mill wastes (Figures 4-1, 4-2, and 4-3). However, the insect communities in this stream are not very diverse (refer to Table 3-1) or stable as reflected in wide annual variations in density and taxa. This indicates that significant improvement needs to be made before the stream is comparable to other streams in the area.

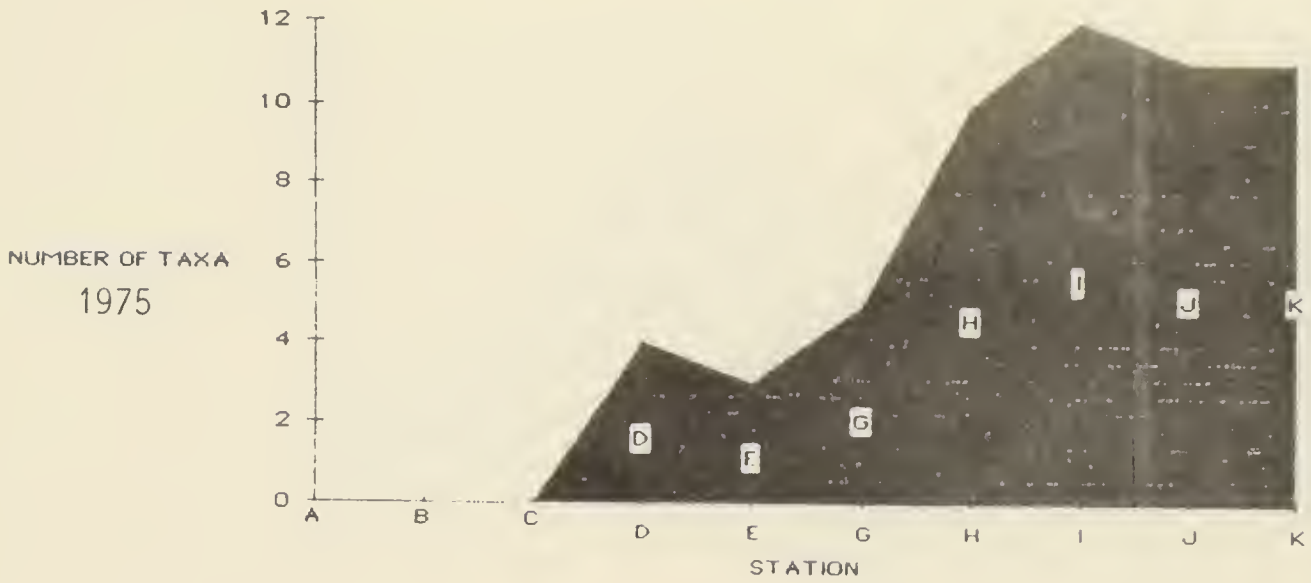
The Clark Fork River is further in the recovery process than Silver Bow Creek (Figures 4-1, 4-2, and 4-3). The reactivation of liming at Warm Springs Ponds 2 and 3 in 1963-1964 (refer to Figure 1-1) gave the Clark Fork an eight to ten year headstart on the recovery process in Silver Bow Creek. Like Silver Bow Creek, the Clark Fork has continued to respond to remediation efforts which principally include wastewater treatment of the Weed Concentrator discharge, commencing in 1972. All stations have shown gradually increasing densities and diversity since 1972.

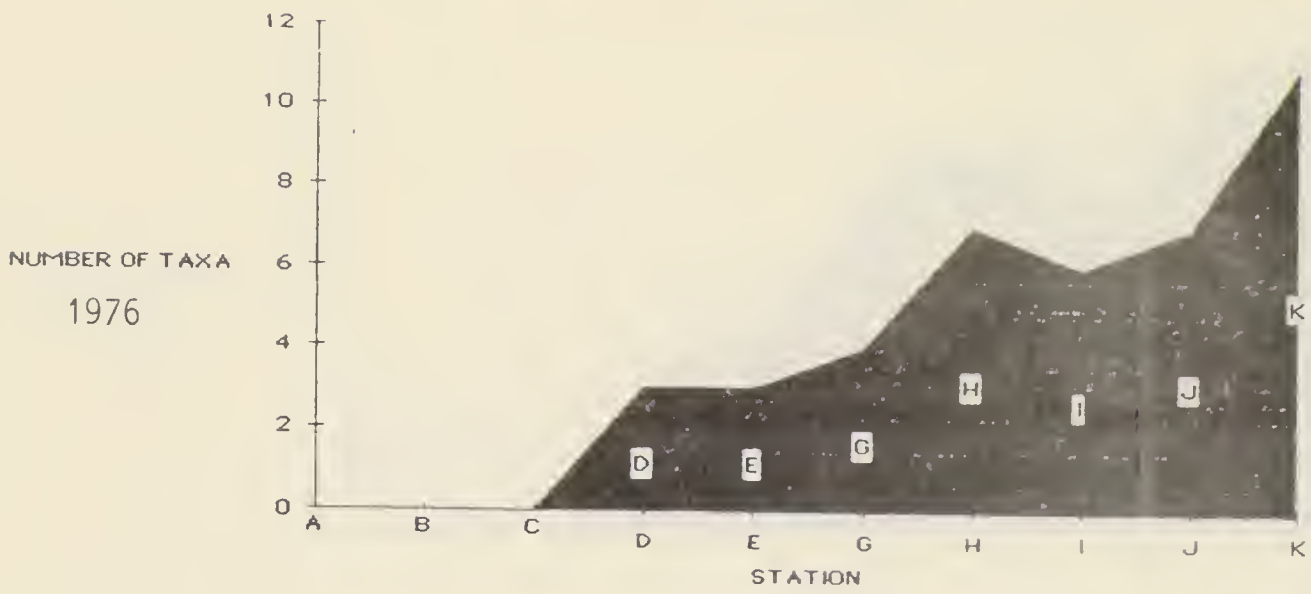
Phillips (1985) suggested that increasing concentrations of trace metals downstream of the Warm Springs ponds is responsible for decreasing numbers of fish per mile. This phenomenon, if it exists, is possibly retarding greater improvement in aquatic insect community composition. The diversity values for various stations shown in Table 3-1 indicate that all of the stations need to make progress to meet

FIGURE 4-1

NUMBER OF TAXA PER STATION BY YEAR FROM 1975-1977

(Based upon Family-level identifications)





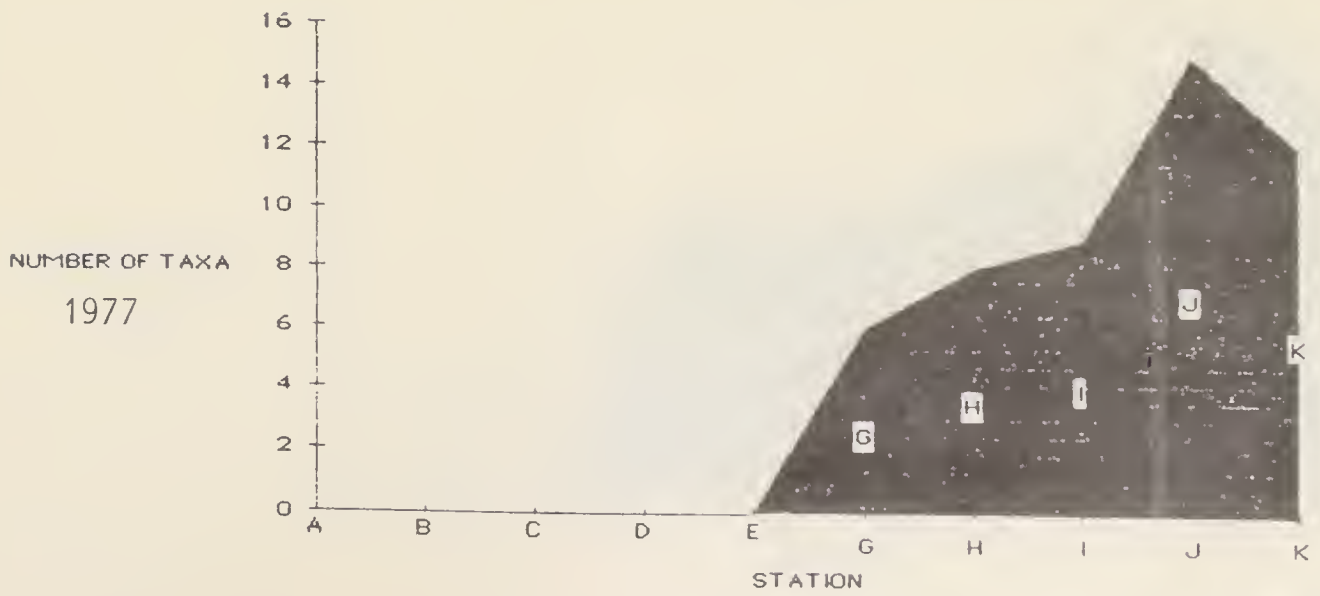


FIGURE 4-2

NUMBER OF TAXA PER STATION BY YEAR FROM 1978-1980

(Based upon Family-level identifications)

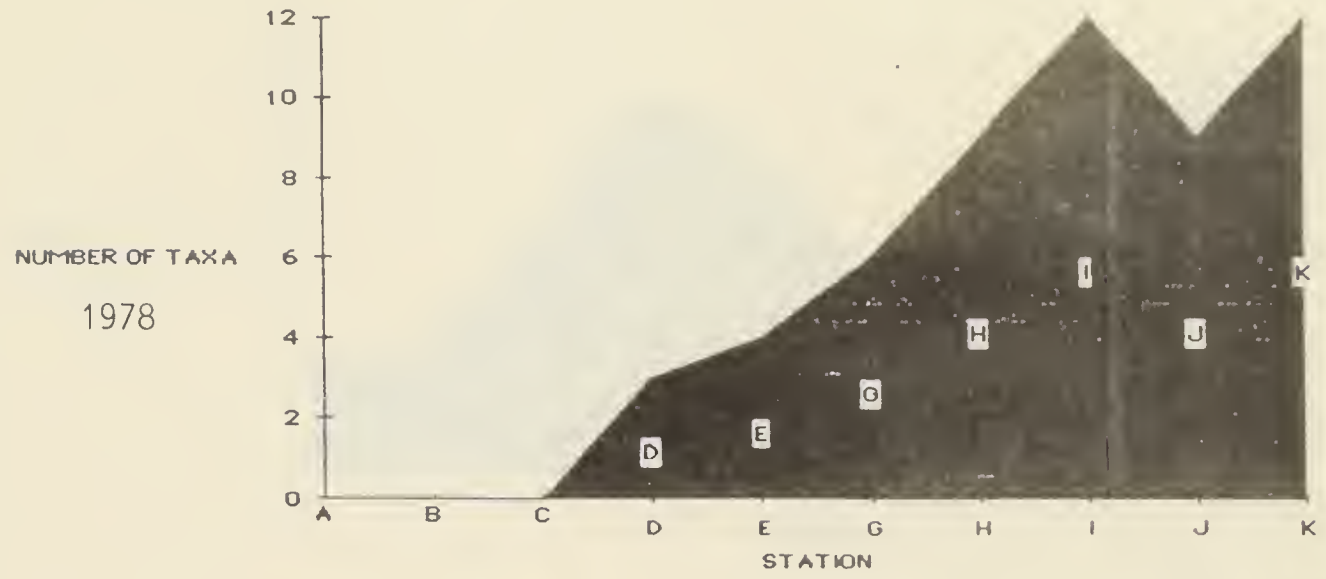
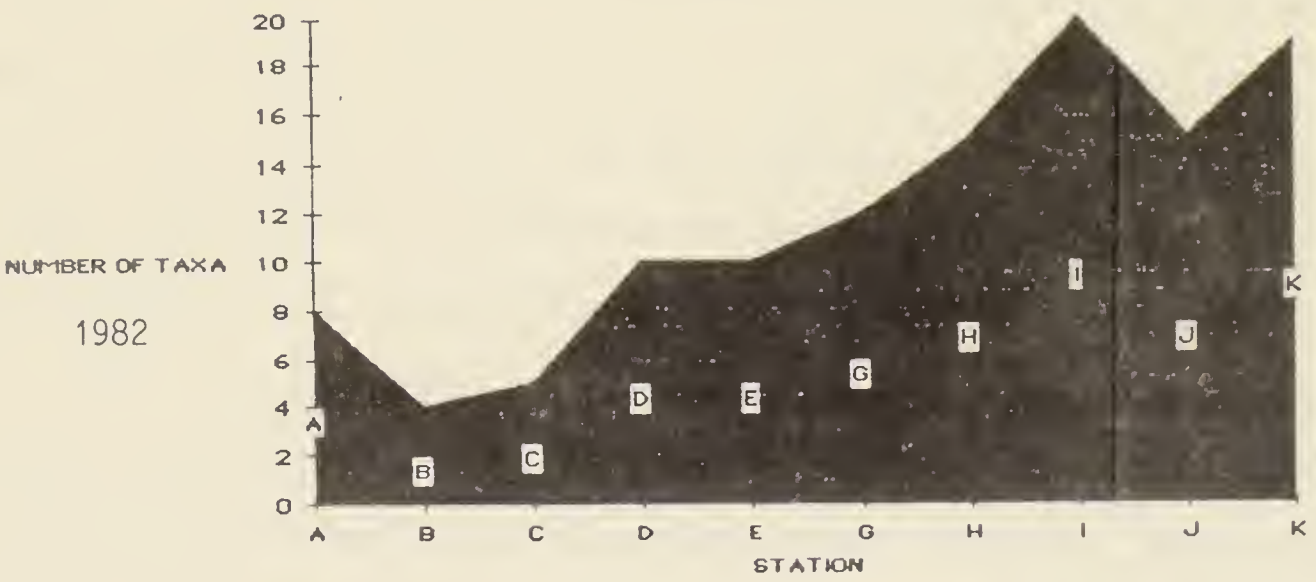
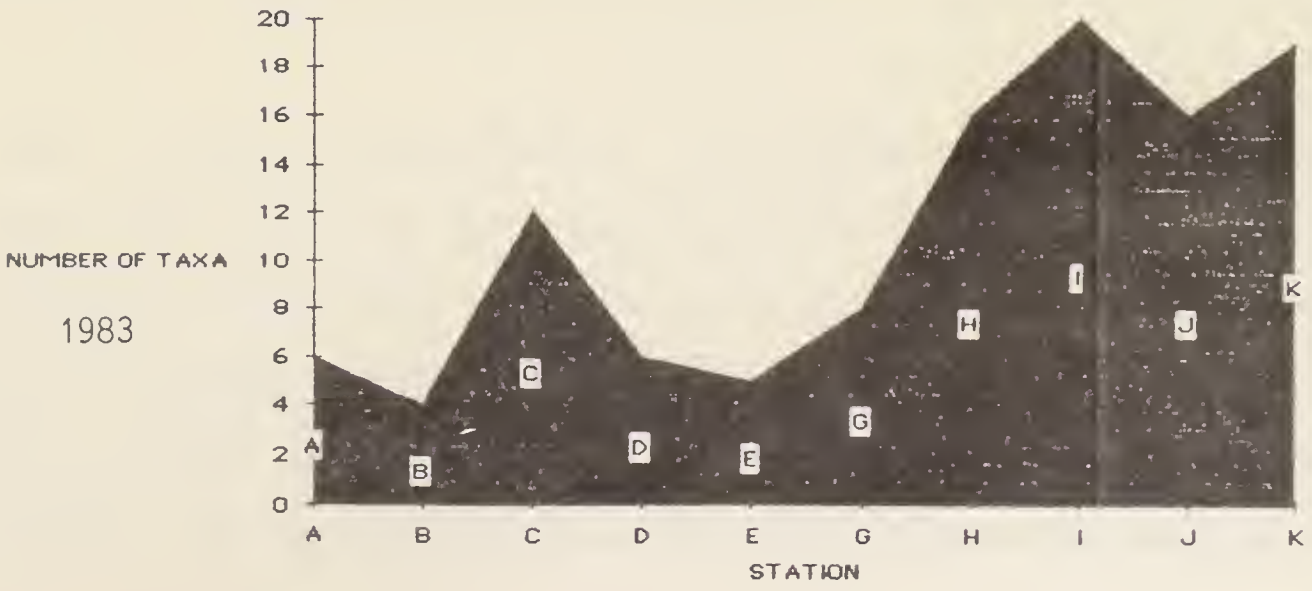


FIGURE 4-3

NUMBER OF TAXA PER STATION BY YEAR FROM 1981-1983

(Based upon Family-level identifications)





Wilhm's (1970) definition of clean waters (those having diversity values in the 3.0 to 4.0 range).

The historic aquatic insect data for Silver Bow Creek/Clark Fork River is a substantial resource for monitoring future remediation efforts. The data from 1980 through 1984, which includes identifications to species is particularly valuable.

Future collections of aquatic insects should be made using the faunal approach described by Elliott (1971). Faunal surveys are not quantitative studies, but rather are undertaken to discover which species are present and to estimate relative abundance at each station. An important aspect of faunal surveys is to cover a large area of streambottom to assure collection of rare species: rare species may well be the most important in monitoring changes in water quality. The faunal survey approach to sampling will better meet the needs of entities monitoring the progress of remediation efforts than attempts at intensive quantitative studies; they will also be very comparable to the work that has been done since 1972; and finally, they will be more cost-effective than quantitative studies.

The SBC RI-Algae Investigation (MultiTech and OEA Research 1986) indicates that algae in the Warm Spring Ponds may be bioconcentrating trace metals. Data from aquatic insect collections indicate that high numbers of Cheumatopsyche and Hydropsyche caddis flies reside directly below the ponds and these insects are probably feeding heavily on these algae. This area also contains the highest density of trout in

the study area, probably due to lower concentrations of trace metals than found downstream, combined with an abundant food source. Tissue samples from these insects should be analyzed for trace metals. The insect population should be sampled to determine if physical abnormalities are common. Finally, consideration should be given to harvesting the Cheumatopsyche population on a regular basis as a method of removing metals from the river system.

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DRAFT

SILVER BOW CREEK REMEDIAL INVESTIGATION

MACROINVERTEBRATE INVESTIGATION

ATTACHMENT I

DATA SUMMARIES FOR REVIEWED REPORTS

MultiTech

TABLE I-1

SAMPLING STATION DATA FROM SPINDLER (1959)

Map 2-1 ID Letter	Total No. of Organisms	% Sensitive	Avg. No. of Organisms Per Sq. Ft.	Avg. No. of Sensitive Organisms Per Sq. Ft.
B	0	0	0	0
D	1	0	0.1	0
* H	10	10	1.1	0.1
I	84	5	7.0	0.33
J	536	14	38.3	5.3
K	293	6	32.6	1.9

* At Station H, The Warm Springs Ponds were just under construction at this time.

TABLE I-2

SAMPLING STATION DATA FROM AVERETT (1961)

Map 2-1 Id. Letter:	H		I		J		K		
Year:	1958	1960	1958	1960	1958	1960	1958	1959	1960
Diptera	0	38	30	137	7	70	129	455	18
Trichoptera	0	2	2	0	4	7	202	80	16
Plecoptera	0	4	0	3	0	12	35	6	50
Gastropoda	0	0	12	0	0	0	0	0	0
Oligochaeta	0	0	0	0	0	0	0	0	0
Coleoptera	0	0	1	0	3	0	17	8	0
Ephemeroptera	0	0	2	19	0	0	19	18	14
Other	0	0	1	0	0	0	6	0	0
TOTAL NUMBER	0	44	48	159	4	89	408	567	98
AVERAGE NUMBER PER SQ. FT.	0	5.5	6	19.9	0.5	11	51	71	8.2

TABLE I-3

SUMMARY OF POPULATION DATA, 1972-1975

FROM DENT (1976)

MAP 2-1 Id No:	E				F			O				H		I				J				K			
Year:	1972	1973	1974	1975	1972	1973	1974	1972	1973	1974	1975	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Plecoptera																									
Perlidae	6	7	38	4	1		2			3						2				14				1	10
Perlodidae	6		3	4			1										1	2			15	21		8	7
Pteronarcoidae		1	9	9		1	1			2	1					20	9		3		5	10		1	3
Nemouridae																						1	1		
Chloroperlidae		12		14							1								1				1		2
Ephemeroptera																									
Heptageniidae	34	3	141	104		3	7			2							13							2	
Baetidae	85	4	66	75			32			17	7					30		9	29	16	7	1	21	38	20
Trichoptera																									
Hydropsychidae	8	58	621	4	115	128	303	166	397	2044	1485		222	2	1	829	384	20	21	1630	67	220	16	743	294
Brachycentridae		2	2				2			1				1		7	1	1			1			2	
Leptoceridae	1				1	3	3	1						1		1		1				12		101	
Rhyacophilidae	4	2	1	1		1																			
Lepidostomatidae		16															1								
Helicopsychidae																					1				
Limnephilidae										2						3									
Hydroptilidae			1																						
Coleoptera																									
Elmidae	1	27	18	24		12	4			2	5					22	2	2	11	20	28	3	25	66	30
Haliplidae						1																			
Diptera																									
Rhagionidae		45	19	2	8	4	39	1	5	3	11		25		1	174	7	4	6	20	14	1	7	119	31
Simuliidae	3		1029	126		5	249			21	107		402			87	62		4	5	2	2	1	135	4
Tendipedidae	42	171	114	1	6	11	67		69	34	11		262		57	34	4	28	11	50	26	13	41	123	69
Tipulidae	2	16	3	2	4	4	7		20	5	3				4	1	1	29	35	8	4	42	2	8	7
Anthomyiidae						1																			
Stratiomyiidae																									
Tabanidae													9				17								
Hemiptera																									
Corixidae											2														
TOTAL TAXA	11	13	14	13	6	12	13	3	4	12	10		5	3	4	12	12	9	9	8	11	11	9	13	11
TOTAL/SQ. FT.	192	364	2065	370	135	174	917	168	491	2136	1633		920	4	63	1210	502	96	121	1763	170	** 115	1347	477	

TABLE I-4

SUMMARY OF POPULATION STATISTICS, 1972-1975

FROM DENT (1976)

Map 2-1 Id. Letters:	E	F	G	H	I	J	K
Avg. No./Sq. Ft.							
1972	192	135	NS*	169	4	96	325
1973	364	174	NS	491	63	121	115
1974	2065	910	NS	2136	1210	1763	1347
1975	372	NS	920	1633	502	170	477
Total No. Taxa							
1972	11	6	NA*	3	3	9	11
1973	13	12	NA	4	4	9	9
1974	14	13	NA	12	12	8	13
1975	14	NA	5	10	12	11	11
Taxa % Occurrence							
1972	73	40	NA	20	29	69	NS
1973	65	60	NA	20	20	45	45
1974	82	76	NA	71	71	47	76
1975	74	NA	26	53	63	68	58
Diversity Index							
1972	4.4	2.4	NA	0.9	3.3	4.0	4.0
1973	4.7	4.9	NA	1.1	1.7	3.8	3.9
1974	3.9	4.1	NA	3.3	3.6	2.1	3.8
1975	5.1	NA	1.3	2.8	4.1	4.5	3.7
Mean Diversity ($\bar{d}$)							
1972	2.30	0.89	NA	0.16	1.50	2.39	1.73
1973	2.49	1.83	NA	0.90	0.57	2.65	2.38
1974	1.99	1.87	NA	0.37	1.68	0.57	2.20
1975	2.45	NA	1.74	0.58	1.32	2.61	1.97
Measure of Equitability							
1972	0.63	0.33	NA	0.25	1.00	0.73	0.33
1973	0.62	0.42	NA	0.50	0.50	0.98	0.78
1974	0.36	0.38	NA	0.08	0.33	0.25	0.46
1975	0.50	NA	0.80	0.20	0.25	0.73	0.45

* NS, NA = No sample, not applicable

TABLE I-5

DATA COLLECTED DURING SUMMER/FALL OF 1970

FROM USEPA (1972)

Station	Dent's Numbers	Avg. No./ Sq. Ft.	Avg. No. Taxa/ Sq. Ft.	Taxa % Occurrence	Diversity Index
Warm Springs	4 (I)*	8	1.1	15	5.5
Dempsey Br.	5	897	4.3	49	6.1
Deer Lodge	6 (J)*	715	4.5	51	6.6
W-T Bridge	7	639	5.3	62	8.2
Garrison	8 (K)*	342	5.5	54	8.2

* Map 2-1 identification letters

TABLE I-6

AVERAGE NUMBER PER SQUARE FOOT

Map 2-1 Id. Letters:	I				J				K			
*Publication:	1/2	3	4	5	1/2	3	4	5	1/2	3	4	5
Plecoptera												
Pteronarcidae	-/2	1	P**	NS**	-/-	1	NS	4	10/1	31	NS	P
Chloroperlidae				NS			NS				NS	
Perlodidae				NS	2/-		NS		21/8		NS	P
Perlidae	-/3			NS	-/14		NS		-/1		NS	
Nemouridae				NS			NS				NS	
Ephemeroptera												
Baetidae	-/30			NS	9/16	3	NS	111	1/38		NS	138
Ephemerellidae				NS			NS				NS	
Heptagenidae				NS			NS		-/2		NS	
Trichoptera												
Hydropsychidae	2/829		P	NS	20/1630	174	NS		220/743	340	NS	917
Brachycentridae	1/7			NS	1/-	11	NS		-/2	2	NS	4
Leptoceridae	1/1			NS	1/-	17	NS		12/101	1	NS	
Rhyacophilidae				NS			NS				NS	
Lepidostomatidae				NS			NS				NS	
Helicopsychidae				NS			NS				NS	3
Limnephilidae	-/3			NS			NS				NS	1
Hydroptilidae		1		NS		46	NS			27	NS	15
Coleoptera												
Elmidae	-/22			NS	2/20		NS		3/66	8	NS	13

* Publications:
1 = Dent (1972)
2 = Dent (1974)
3 = EPA (1972)
4 = Fox (1972)
5 = EPA (1974)

** P = Present
** NS = Not Sampled

TABLE I-6

AVERAGE NUMBER PER SQUARE FOOT

Map 2-1 Id. Letter:	I				J				K			
*Publication:	1/2	3	4	5	1/2	3	4	5	1/2	3	4	5
Diptera												
Rhagionidae	-/174			NS	4/20	90	NS		1/119		NS	3
Simulidae	-/87	7	P	NS	-/5	21	NS		2/135	12	NS	20
Tendipedidae	-/34	2	P	NS	28/50	871	NS		13/123	39	NS	75
Tipulidae	-/1			NS	29/8		NS		42/8	1	NS	120
Anthomyiidae				NS			NS				NS	
Stratiomyiidae			P	NS			NS				NS	
Tabanidae				NS			NS				NS	
TOTAL TAXA:	4/12	4	5	NS	9/8	9	NS		10/13	9	NS	13

* Publications:
1 = Dent (1972)
2 = Dent (1974)
3 = EPA (1972)
4 = Fox (1972)
5 = EPA (1974)

** P = Present
** NS = Not Sampled

TABLE I-7

SUMMARY OF 1980-1984 POPULATION DATA FOR SILVER BOW CREEK

FROM HARNER-WHITE (1980) AND CHADWICK AND ASSOCIATES (1983, 1984, 1985)

STATION	A				B				C				D					E				
YEAR	1981	1982	1983	1984	1981	1982	1983	1984	1981	1982	1983	1984	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
Ephemeroptera																						
Ameletus sp																						13
Baetis bicaudatus		4		3		7				7	7				18							
Eperous grandis												3										
Cinygmula															4							
Ephemerella infrequeus		7	3								3											
Callibaetis			3																			
Rithrogena hageni											7											
Plecopetera																						
Chloroperlidae			7										4								17	
Pteronarcella badia				3																		
Doroneuria theodora																3				4		
Skwala											7				4							
Zapada cinctipes											3			4								
Trichoptera																						
Limnephilidae																				4		
Arctopsyche grandis																	3					
Brachycentrus americanus									43				4	11	22			4	172	11		100
Cheumatopsyche sp.		4							14	14				22	25		7		302			
Hydropsyche spp		29		43			3		29	14	20	27		187	2596	353	519		8027	1292	93	946
Lepidostoma sp.								3														
Rhyacophila acropedes															14		3					
Rhyacophila angelita														7	4							
Glossosoma sp		7																	14			
Hydroptila											3									4		
Diptera																						
Antocha							3	3	14		3	3		14		3			29			30
Atherix pachypus											3		7	4			20	7	79	4		
Chelifera sp.	4	22		3		7			682	68	320	33	291	176	707	163	20	284	251	11	20	27
Cricotopus			3	23			7	7			83	100				30					27	36
Diamesa				7				3				156										3
Ephydra								3														13
Hemerodromia						4						3										
Hexatoma		4												4			3		14		3	7
Orthocladius			30	10				7			67	203				13				4		40
Pagastia			43	7			33				356	10				83					33	
Parametriocnemus			20	43			3	7			266	166				13	27				50	63
Simulium														4								7
Tipula			3																36			17
Chironomidae pupa	50	1949	13		44	1842	17		696	2519	136		104	496	1312	7		748	2039	728	70	20
Limnophora	4	7			11		3		65		27								7			
Palpomyia									7													
Forcipomyia					4																	
Coleoptera																						
Heterlimnius sp.	4												7	7		3	3	7	36			
Optioservus quadrimaculata																	3		14			
Oreodytes														4			3					
Brachytus										14				4	4							
TOTAL TAXA	16	15	9	10	7	11	6	9	12	12	16	11	12	20	15	9	12	12	17	14	7	14
TOTAL NO./SQ FT.	80	2248	168	162	88	2661	69	69	1557	2701	1314	710	417	970	4824	671	617	1086	11049	2073	313	1399

TABLE I-8

SUMMARY OF 1980-1984 POPULATION DATA FOR THE CLARK FORK RIVER FROM HARNER-WHITE (1980) AND CHADWICK AND ASSOCIATES (1983, 1984, 1985)

MAP 2-1 Id. No.	F					G					H				
Year:	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
Ephemeroptera															
Baetis bicaudatus	710	1508	420	43	80	968	1580	460			108	474			13
Baetis tricaudatus	151	14		60	40	323	86	129	206	27					
Cinygmula sp	215	1766	302	153	226	22				13					
Drunella doddsi	43	72	22	13	13										
Drunella grandis	194	47	43	7	13										
Ephemerella infrequens	172	1077	223	96	213										
Paraleptophlebia heteronea	43	115	65	53	67		14								
Rithrogena hageni	172	1292	948	626	280										
Serratella tibialis	43	57	47												
Callibaetis sp													14		
Rithrogena robusta		14	65	30											
Tricorythodes															
Epeorus sp		14													
Caudatella hystrix				130											
Plecaptera															
Hesperoperla pacifica	43	215	68	243	143	5			13	3					
Isoperla fulva	43	115	129	593	919	194	129	460	73	43				13	
Pteronarcella badia	5		47	113	353			29	33	53					
Skwala sp	22			30	27				40						
Capniidae			129		13			14							
Chloroperlidae	108	302	22	20		237	244								
Isogenoides zionensis									7						
Zapada cinctipes		14	14	27	27										
Doroneuria theodora				13											
Coloeptera															
Brychius						5					5				
Laccobius															
Optioservus quadrimaculata	602	460	481	73	413	215	57	302	206	93	108	57	302	799	533
Oreodytes	64								13		22		14		
Zaetzevia sp	108	100	194	57	106	22		57	33	73			43		
Deronectes															
Haliplus									13			43	86	93	
Narpus			47												
Trichoptera															
Arctopsyche grandis	43	158	83	546	440			14							
Brachycentrus americanus	151	230	39	3	173										
Cheumatopsyche sp		14	7	27	27	1722	6548	7970	8112	3090	12051	33660	72145	41359	15798
Glossosoma sp	64	1536	661	1858				29	27	27					
Helicopsyche sp			4					100	20	3					
Hydropsyche sp	1011	3791	1282	1865	5008	20315	30098	9205	12368	10017	3615	2757	976	6806	14625
Hydroptila sp		86				86	4	29	7		258	43	57	280	
Lepidostoma sp	237	1910	57	17	1878					13					
Nectopsyche lahontanensis					13			29			22				
Oecetis sp.		14				86		14	13	53					106
Oxyethira sp															
Rhyacophila acropedes	43	115	11	93	206										
Agapetus			11												
Ceraclea															
Rhyacophila oita	11		14	16											
Micrasema				30	27										
Diptera															
Cricotopus				360	1971				146	160					27
Antocha sp	108	689	83	116	200	237	43	144	27	93	86	86	144		186
Atherix pachypus						5	86	214	40	33	43	129	29	186	1905
Chelifera sp	280	287	140	140	13			14							
Eukiefferiella				3					20						
Hemerodromia sp		86			13						22	57	43		
Hesperoconopa sp	22														
Hexatoma sp	86	402	147	73	106	5	230	144	37	3			14		
Limnophora sp				13											
Microspectra				383	333				80					213	27
Orthocladius				47	240				7	80					27
Pagastia				20											
Parametriocnemus				120	693				480	559				706	573
Simulium sp	22	72	39	30	13	2539	1106	976	1259	653	9942	12407	9487	21071	2757
Tipula sp	64	4				5		43	7						
Chironomidae	1144	3188	607		13	3314	5600	4092	133	106	1895	7696	5816	93	80
Dicranota			4												
Palpomyia												14			
TOTAL NUMBER	6037	19807	6473	6663	14479	30381	45825	24985	23620	15328	29187	58536	99850	79279	37060
TOTAL TAXA	37	40	39	43	36	29	19	33	31	22	23	23	26	15	17

TABLE I-8

SUMMARY OF 1980-1984 POPULATION DATA FOR THE CLARK FORK RIVER

FROM HARNER-WHITE (1980)

AND CHADWICK AND ASSOCIATES (1983, 1984, 1985)

MAP 2-1 Id No	I					J					K				
Year	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984	1980	1981	1982	1983	1984
Ephemeroptera															
Baetis bicaudatus	188	3231	187		3	4433	2657	1278	306	80	145	3217	1924	380	216
Baetis tricaudatus	48	14		133	10	1571	129	187	93	13	32	29	761	13	
Cinygmula sp	5			7	13										13
Drunella doddsi			4		3										
Drunella grandis															
Ephemerella infrequens						22	43	14	53	13	11	72	100	226	106
Paraleptophlebia heteronea															
Rithrogena hageni											11	14	57	27	
Serratella tibialis															
Callibaetis sp															
Rithrogena robusta															
Tricorythodes												43		20	3
Epeorus sp												14			
Caudatella hystrix															
Plecoptera															
Hesperoperla pacifica		4		7	37					266		18			40
Isoperla fulva	27		29	40	23	194	144	603	1865	240	22	100	517	100	57
Pteronarcella badia	16	100	201	386	376	16	14	72	106	193		29	57		
Skwala sp.	22	14	4	83	67	54	201	100		93	5	90	100	3	63
Capniidae			14	3							22				
Chloroperlidae	75	359	14	13	3	473	201	86			124	617	232	67	7
Isogenoides zionensis							129					180	14	40	
Zapada cinctipes				3								14	14		
Doroneuria theodora															
Coloeptera															
Brychius						5									
Laccobius	5														
Optioservus quadrimaculata	5	890	775	30	77	1614	359	890	1265	679	11	804	1091	240	133
Oreodytes		14					14								
Zaitzevia sp.	5	129	86		13	5	14	29	120	27				20	7
Deronectes			4											7	
Haliplus															
Narpus															
Trichoptera															
Arctopsyche grandis			14	13	20	5	43					14			10
Brachycentrus americanus		86		27	40	387	115	57		253	5	100	14	20	
Cheumatopsyche sp.	11	560	1637	683	353	323	115	316	93			29	29	40	27
Glossosoma sp.			14	33	13		14				5	14			
Helicopsyche sp.		14	29		83	22				13		14		7	
Hydropsyche sp.	473	23163	7869	2424	892	7984	9482	6764	14266	5168	16	8113	1637	2005	2258
Hydroptila sp.	16	2298	14	20	27	2216	13613	330	3650	9644	81	1809	2154	2817	236
Lepidostoma sp.	16			17	7	22	57	29	13		5	302	172	273	106
Nectopsyche lahontanensis				7		22						14			
Oecetis sp.		287	29	10	43	108	129		13	53		57		60	10
Oxyethira sp.						22									
Rhyacophila acropedes			14	3	17										
Agepetus															
Ceraclea							29						43		
Rhyacophila oula															
Micrasema															
Diptera															
Cricotopus				27	27				2118	240				246	53
Antocha sp.		330	215	27	23	2496	704	416	519	626		201	43	67	333
Atherix pachypus	11	1152	115		17	70	86	589	573	879		187	57		17
Chelifera sp.		43	57	10	10	689	129	14	226	120	11			7	
Eukiefferiella				3					293					120	
Hemerodromia sp.		43				194	589	72	133				29	7	
Hesperoconopa sp.			14			5		14					14		
Hexatoma sp.	5	47	115	30	30	16	215	115	83	186	5	86	388	86	73
Limnophora sp.						38									
Microspectra				17	7					80					13
Orthocladius				40						213					13
Pagastia				7	23										13
Parametriocnemus				380	333				3716	1492				4822	1086
Simulium sp.	129	115	144	966	146	430	72	431	1359	1066	178	57	187	679	27
Tipula sp.	11		4	96	53	22			3						
Chironomidae	199	1306	819	100	240	1852	3703	1882	466	160	299	3245	5356	240	113
Dicranota					3										
Palpomyia			14												
TOTAL NUMBER	1267	34227	12449	5714	3082	25423	31431	14302	31651	22085	968	19519	15002	12716	5090
TOTAL TAXA	23	27	32	36	40	40	36	28	27	29	23	36	29	32	27

TABLE I-9

AQUATIC MACROINVERTEBRATES COLLECTED

FROM WARM SPRINGS CREEK NEAR THE MOUTH

	AVERAGE PER FT²								
	Averett (1961)		Dent (1976)				Fox	EPA	EPA
Taxa	1958	1960	1972	1973	1974	1975	1972	1972	1974
Plecoptera	0	8							NS*
Perlidae					2	1			NS
Perlodidae						1			NS
Pteronarcidae			2		7	44	P*		NS
Chloropulidae				3					NS
Trichoptera	2	15							NS
Hydropsychidae			2	1	52	8	P	5	NS
Leptoceridae			1		4				NS
Rhyacophilidae				1				8	NS
Brachycentridae									NS
Hydroptilidae								19	NS
Ephemeroptera	.25	0							NS
Baetidae			2		43	104	P	1	NS
Heptageniidae					1	2			NS
Ephemerellidae								1	NS
Diptera	2								NS
Simulidae		1		72	387	50	P	1	NS
Tipulidae		5		41	8	9	P		NS
Tendepedidae		1		192	57	5	P	54	NS
Rhagionidae		3	1						NS
Stratiomyidae				1					NS
Coleoptera	.25	1							NS
Elmidae				5	8				NS
Haliplidae				3					NS
TOTAL TAXA	4	7	5	9	10	9	6	7	NS

* NS = Not Sampled P = Present

TABLE I-10

AQUATIC MACROINVERTEBRATES COLLECTED

FROM LITTLE BLACKFOOT RIVER NEAR THE MOUTH

	AVERAGE PER FT²								
	Averett (1961)		Dent (1976)				Fox	EPA	EPA
Taxa	1958	1960	1972	1973	1974	1975	1972	1972	1974
Plecoptera	0	9	NOT SAMPLED						
Chloroperlidae								13	3
Perlidae								3	10
Pteronarcidae								23	23
Trichoptera	22	8							
Brachycentridae								65	28
Hydropsychidae								4	35
Lepidostomatidae								517	5
Glossosomatidae								5	
Helicopsychidae								3	12
Hydroptilidae								58	4
Leptoceridae								30	
Rhyacophilidae									12
Ephemeroptera	8	1							
Baetidae								110	570
Heptageniidae								10	49
Diptera	8								
Simulidae		16							501
Tendepedidae		3						121	292
Rhagionidae		5							1
Tipulidae		3						2	10
Coleoptera	1	P							
Elmidae								83	100
TOTAL TAXA	4	8	NS	NS	NS	NS	NS	17	15

SILVER BOW CREEK REMEDIAL INVESTIGATION

MACROINVERTEBRATE INVESTIGATION

ATTACHMENT II

GRAPHS OF DATA

MultiTech

FIGURE II-1

MONTHLY READINGS FROM AUGUST 1975 TO NOVEMBER 1979

AT OPPORTUNITY

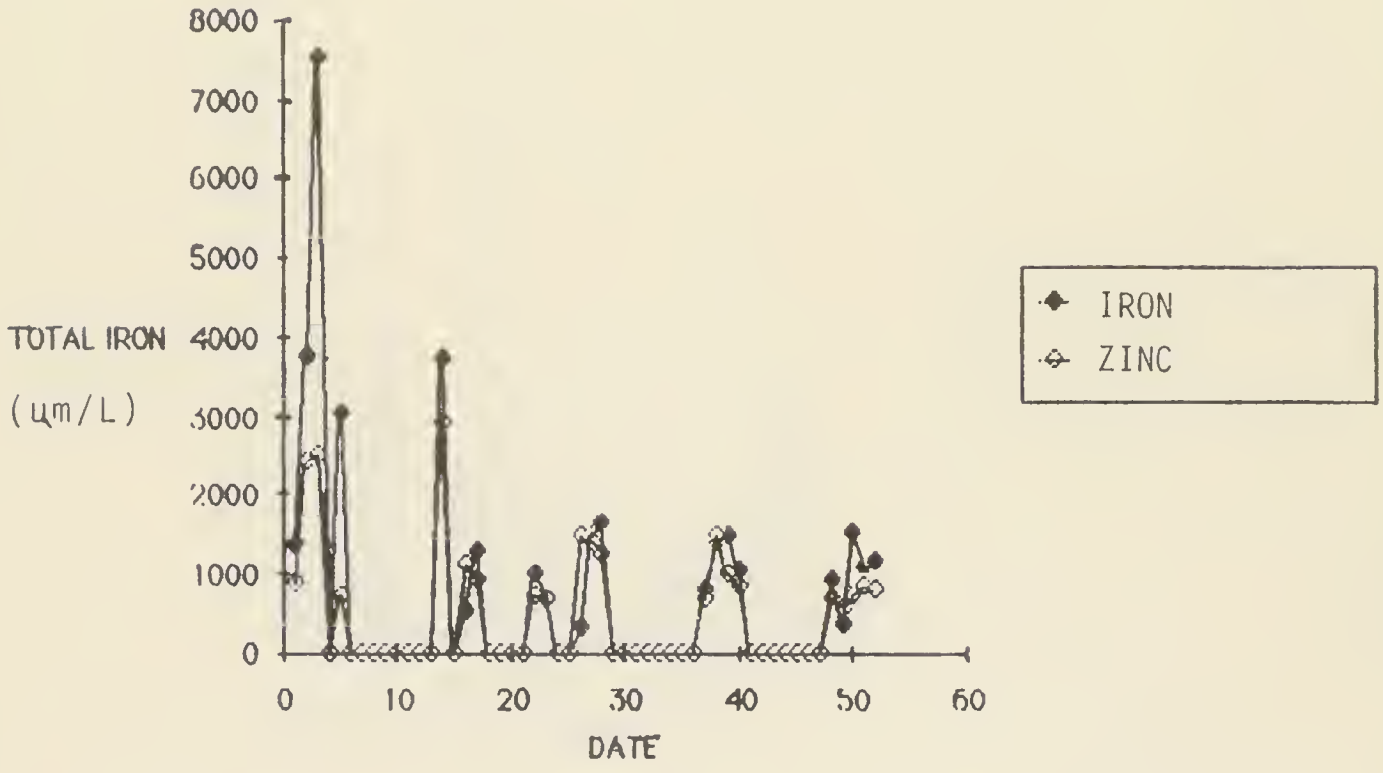


FIGURE II-2

MONTHLY READINGS FROM MARCH 1975 TO JULY 1980

AT MILL-WILLOW BYPASS

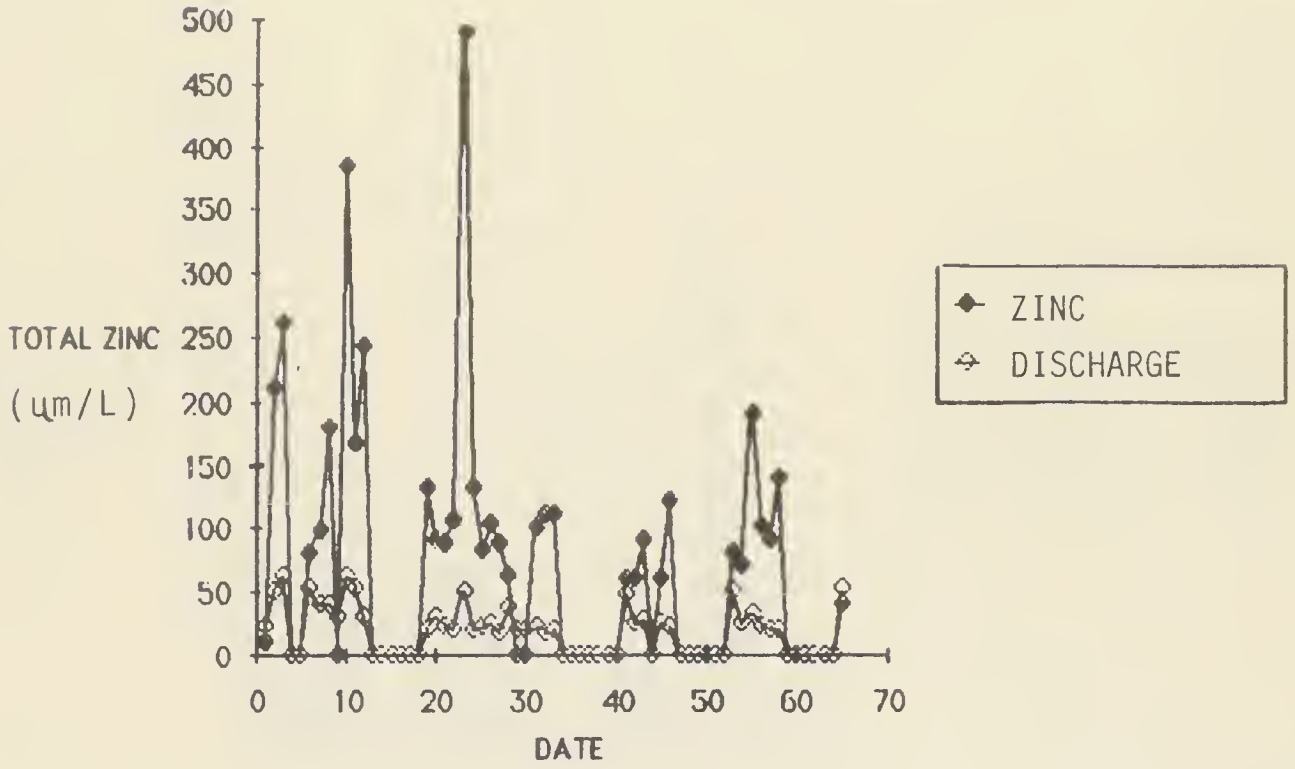


FIGURE II-3

MONTHLY READINGS FROM MARCH 1975 TO JULY 1980

AT MILL-WILLOW BYPASS

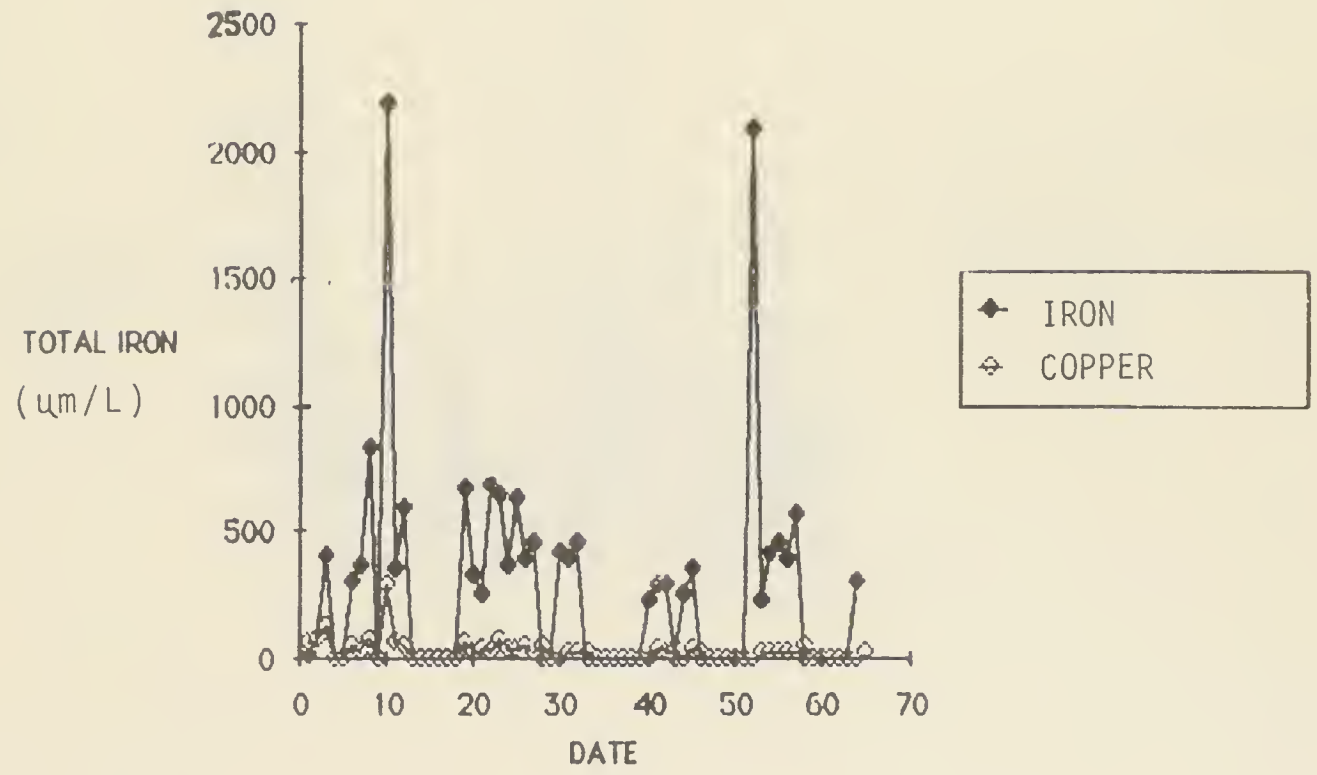


FIGURE II-4

MONTHLY READINGS FROM MARCH 1975 TO DECEMBER 1981

FROM POND 2 DISCHARGE

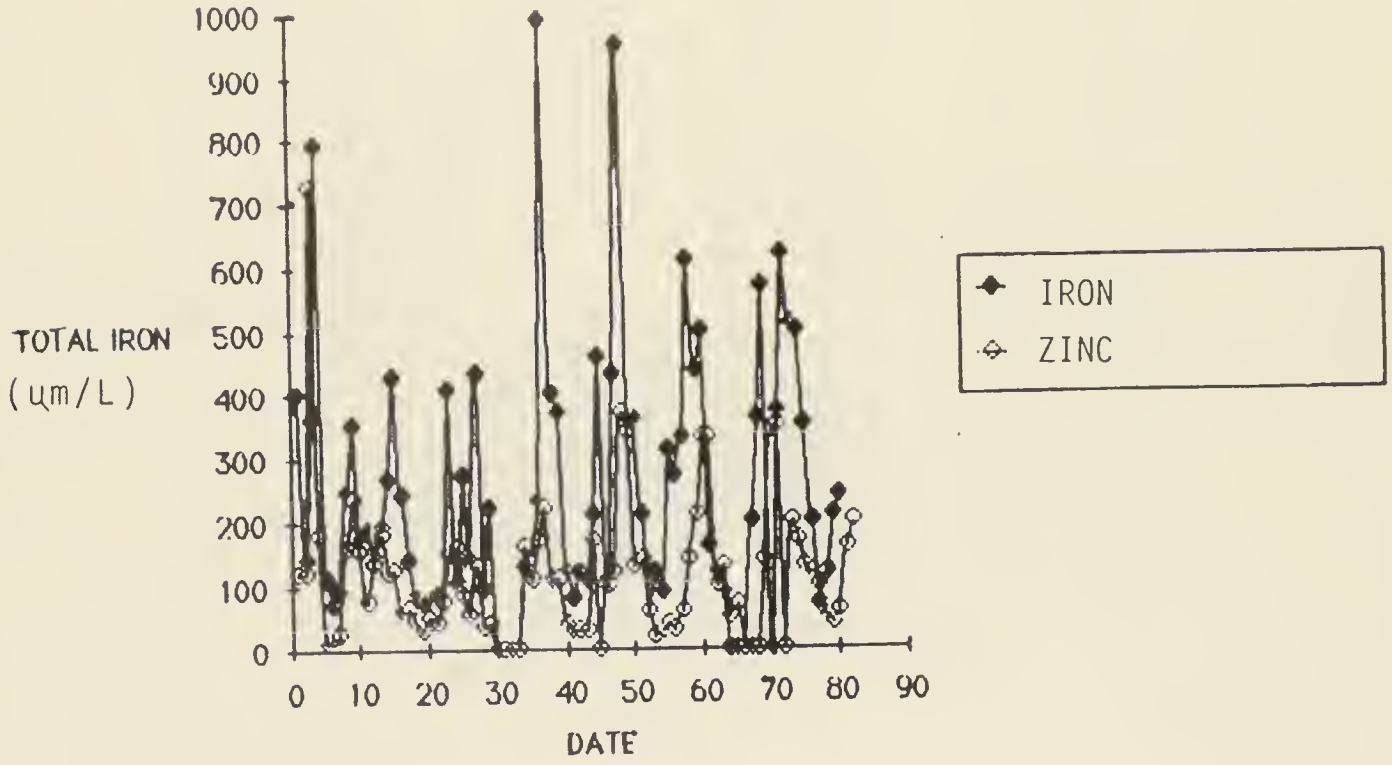
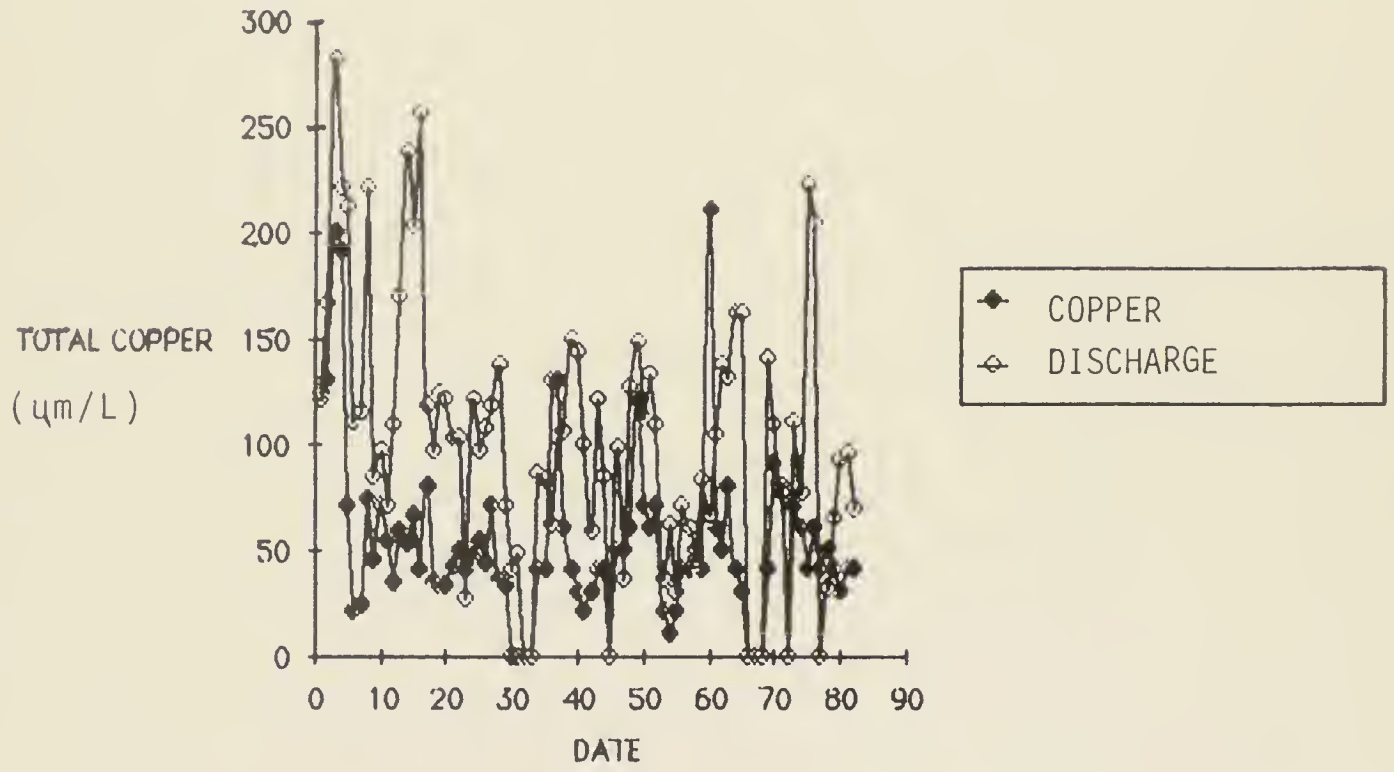


FIGURE II-5

MONTHLY READINGS FROM MARCH 1975 TO DECEMBER 1981

FROM POND 2 DISCHARGE